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COLLECTED ESSAYS AND ARTICLES ON PHYSIOLOGY AND MEDICINE

BY

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INTRODUCTION

At the present time there are few questions relating to physiology of greater interest and importance than the one which is the subject of this essay. Since the publication of the experiments of Fick and Wislicenus, in 1866, a large number of observations have been made, which are brought forward as evidence that the muscular system of a fully-developed man or other animal is simply a perfected mechanical apparatus, like an artificially-constructed machine, which accomplishes work, not at the expense of its own substance, the material consumed being restored by food, but by using the food itself, the force-value of which can be accurately calculated, as one can calculate the dynamic value of the fuel consumed in a steam engine. These observations have led some physiologists to adopt a kind of materialism, the fundamental idea of which is that the only matter concerned by its transformations in the production of muscular force is food. If a theory with this idea as its basis could be substantiated, it would indeed be an advance in positive knowledge, so great that its importance could hardly be exaggerated; and it is not surprising that the simplicity of the explanations of various physiological processes afforded by such an hypothesis should bring to its support many earnest and able advocates.

Since the discovery by Mayer of the law of the correlation and conservation of forces, which is now universally accepted, it has seemed impossible to successfully controvert the notion that every manifestation of force in

animal bodies, not excluding man, is dependent on some kind of transformation of matter. Physiologists can not comprehend the idea of the existence of any force unconnected with material changes, any more than it is possible to conceive of the absolute destruction of an atom of matter or of the generation or creation of something out of nothing.

Taking Nature as she now appears, there seems to be little or no basis for what may be termed an immaterial physiology. The researches which I have made into the question of the source of muscular power are not in any way opposed to the known relations between matter and force; they have been directed simply toward the solution of the problem whether the food is concerned directly, by its transformations, in the production of muscular power or whether muscular work involves changes in the muscular substance itself, this substance being destroyed as muscular tissue, discharged from the body in the form of excrementitious matter, the waste being repaired by food. The importance of this problem can be appreciated when it is remembered that complete and authoritative treatises on physiology have lately been written on the basis of the idea that food is directly concerned in the production of force, and that the muscular system, like the parts of a steam engine, has no relation to the force developed, except that it consumes food and transforms it into energy, as a mechanical apparatus consumes fuel.

A logical method of inquiry to apply to this question is to disturb the natural balance between ordinary muscular work and the quantity of food, by increasing the work; then to calculate the income and outgo of matter and to ascertain, if possible, what is consumed in the production of force over and above that which can be accounted for by the food taken, assuming that this food is used either in repairing the muscular tissue consumed in the work or in the direct production of the work itself. If it can be shown by such a method of inquiry that excessive and prolonged muscular work consumes a certain quantity of muscular tissue, it then becomes a question whether such work involves processes of destruction and nutrition of muscular substance, differing in kind as well

as in degree from those which take place in ordinary muscular effort. But I shall not attempt here to prejudge any of the questions that will be involved in the discussion of the facts that I have at my command.

THE SOURCE OF MUSCULAR POWER

"It is now an established doctrine that force, like matter, can be neither created nor destroyed. The different forms of force are mutually convertible the one into the other, but they have their definite reciprocal equivalents, and in the transmutation the existing force undergoes no increase or decrease. The force liberated by a certain amount of chemical action will produce a certain amount of heat, and this, in its turn, may be made to accomplish a certain amount of mechanical work. The chemical action has its representative amount of heat, and the heat its representative amount of mechanical work; and the relative value of each is susceptible of being expressed in definite terms. It has been ascertained, for instance, that the force derived from chemical action which will raise the temperature of a pound of water 1° Fahr. will, under another mode of manifestation, lift 772 pounds one foot high; 772 foot-pounds are then said to constitute the dynamic equivalent of 1° of heat of Fahrenheit's scale.

"What is true of force in the inorganic world is equally applicable in the organic. The force manifested by living beings has its source by transmutation from other forms which have preëxisted. The food of animals contains force in a latent state. Properly regarded, food must be looked upon, not simply as so much ponderable matter, but as matter holding locked-up force. By the play of changes occurring in the body the force becomes liberated, and is manifested as muscular action, nervous action, assimilative, secretory, or nutritive action, heat, etc."

The above is quoted from an article by Dr. F. W. Pavy, published in "The Lancet" for November 25, 1876. It contains a proposition which, if happily it were true, would mark an advance in positive knowledge of animal mechanics, the importance of which could hardly be overestimated—reducing the ideas of the physiology of muscular power to a degree of exactness and simplicity most attractive as well as desirable.

I do not propose to discuss here the law of the correlation and conservation of forces, as developed by researches in physics and inorganic chemistry; but it seems to me that the unreserved and absolute application of this law to the mechanics of the living body, particularly in their relations to the source of muscular power, is a ques-

tion for careful physiological investigation and not one that can be accepted simply on the basis of analogy. It is easy to follow the various chemical actions occurring in inorganic matters, to measure the heat produced and to calculate the corresponding equivalents of force; but while one can observe these processes accurately and without serious difficulty, in studying the various changes and transmutations which organic matters undergo in the animal body, problems are met which are perhaps the most intricate and complicated in Nature.

If the proposition advanced by Dr. Pavy were a legitimate and logical deduction from physiological investigations, nothing could be simpler than the mechanism of muscular power, and few would venture to contradict his views. This, however, does not seem to me to be the case. Dr. Pavy's proposition is apparently assumed to be true at the outset, as a condition precedent to his course of reasoning from the results of his observations. When the physiological data do not coincide with the theory under the influence of which his deductions seem to have been made, the error is assumed to be in the imperfection of the observations made by others as well as by himself. There is no suggestion that the theory itself may be faulty. Here seems to be the oft-repeated error of attempting to accommodate experimental facts to a law which is assumed to be invariable in its manifestations and exact in its applications; it is reasoning that a proposition, true as regards the inorganic kingdom, must be applicable absolutely to living bodies; it is bringing forward as evidence that the law is correct, arguments and deductions based mainly on the assumption of the truth of the proposition involved.

In the study of animal physiology, one constantly meets with phenomena that are analogous to nothing which is observed in the inorganic world; and processes, which at first seem to be simple enough in their explanation, have been afterward ascertained to be most complex. A notable instance of the latter is to be found in the history of the connection between respiration and the production of animal heat. In 1775 Lavoisier ascertained that the gas obtained by decomposing oxide of mercury "was better fitted to maintain the respiration of animals

than ordinary air." * Two years after, he confined animals under a bell-glass, and after their death, showed that oxygen had been consumed and carbonic acid produced.† He afterward compared the changes which take place in the air in respiration with the changes produced by the combustion of carbon and proposed the theory that heat is produced by a process in the animal body analogous to combustion.

> "Respiration is merely a slow combustion of carbon and hydrogen, which is in every way similar to that which takes place in a lighted lamp or candle; and, from this point of view, animals which respire are true combustible bodies which burn and consume themselves." ‡

This was the origin of the theory which was afterward developed by Liebig into the doctrine of the carbohydrates and fats as calorific matters, and nitrogenous substances as plastic elements of food.

While the theories of Lavoisier and of his followers greatly advanced a knowledge of the respiratory processes, the more modern researches of Bernard, Brown-Séquard and others, in regard to the influence of the nervous system on calorification, local variations in animal temperature, etc., showed that the production of animal heat is a phenomenon incident to the general process of nutrition and is not due simply to oxidation of non-nitrogenous matters. Although oxygen is consumed, carbonic acid produced and heat generated in the bodies of animals, physiologists do not understand all of the intermediate processes between the appropriation of oxygen by the tissues and the production of carbonic acid. It is not possible to raise the temperature of animals above the normal standard by increasing the supply of non-nitrogenous matters, nor can the production of heat be arrested by depriving animals of the so-called calorific matters. Physiologists have long since recognized the fact that the processes of combustion, such as occur in the inorganic world, are so

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* Lavoisier, "Mémoire sur la nature du principe qui se combine avec les métaux pendent leur calcination, et qui en augment le poids."—"Hist. de l'Acad. Roy. des Sciences," année 1775 ; Paris, 1778, pp. 521 et 525.

† "Expériences sur la respiration des animaux." *Ibid.*, année 1777 ; Paris, 1780, p. 183.

‡ Séguin et Lavoisier, "Premier mémoire sur la respiration des animaux." "Hist. de l'Acad. Roy. des Sciences," année 1789 ; Paris, 1793, pp. 570 et 571.

far modified in the living body that the term "combustion," as applied to animal processes, means merely the appropriation of oxygen and not a simple chemical action resulting in the formation of carbonic acid and water and the production of a definite amount of heat.

Applying the lesson which should be learned from the progress of the theories of animal heat to the study of the source of muscular power, physiologists, as it seems to me, should carefully study all of the facts known in regard to the development, nutrition and disassimilation of muscular tissue. They should carefully weigh these facts before advancing a complete mechanical theory, in which food is regarded as "matter holding locked-up force," and calculating the heat-units and the foot-pounds of force necessarily contained in various alimentary substances.

No one can say why the growth of muscle and the development of muscular power is restricted within certain limits, no matter how much food may be taken and digested; no one can give a reason why a man becomes on an average five feet and eight inches high and weighs one hundred and forty pounds and then maintains about that standard throughout his adult life; why the limit of his muscular endurance is fixed; why, after exhausting one set of muscles, he is still capable of severe work with another; why the animal machine necessarily wears out and the being dies within a certain period; or why a man, with proper physical "training," becomes capable of greater and more prolonged muscular effort, with precisely the same food, than the same man out of training. These questions can not be answered under the assumption that the animal mechanism is like a steam engine, using food as fuel, which food produces a certain amount of work. If a man should take a certain quantity of food and do no work except that required to maintain circulation, respiration and assimilation, there is no evidence that the force "locked up" in the food is evolved in the form of heat; and the heat produced in the body is actually less than under exercise, as is well known. If it is assumed that the force "locked up" in food can not be destroyed, what becomes of this force when the food undergoes its ordinary transmutations and there are no manifestations of force in work performed! Why does the muscular system

need rest and recuperation after prolonged exertion, if it is simply the food which has its force liberated, and not the muscular system which wears itself to the point of exhaustion! When a steam engine performs a certain amount of work, a part of the heat of the fuel is changed into mechanical power. When the same quantity of fuel is consumed and no work is done by the machine, the heat is evolved and no part of it is transformed into mechanical power.

The only way in which certain of these questions can be answered is by making experiments on the living organism under physiological conditions. The results of such experiments should be carefully studied, and then, and then only, may a comparison properly be made between a living mechanism and a machine artificially constructed and operated by familiar methods.

It would be illogical and unphilosophical to assume at the outset that the same methods operate in living bodies as in machines of artificial construction, however attractive such a simplicity of explanation might appear. One may thoroughly understand the principles of ordinary mechanics, but should not necessarily assume that the results of observations and experiments are faulty and imperfect, for the sole reason that they are not in accord with principles ascertained from a study of the forces of inorganic Nature. The physiologists should rather humbly endeavor to discover the laws of living processes, and not seek to force such laws as he comprehends to apply absolutely to animal mechanism. Physiological facts, if definite and well established, should be treated as facts not to be distorted into arguments in favor of laws which have been enacted rather than discovered. Whatever facts in physiology are known have been ascertained by long, patient and difficult research and have generally been established after much discussion and controversy and the apparent opposition of conflicting observations.

The various functions of the human body are so dependent upon and so closely related to each other, that it is difficult, in the present condition of science, for any one but a physiologist to accurately and justly weigh the evidence bearing upon certain physiological questions. In physiological literature, one can often find what appears

to be good authority for diametrically opposite views, between which an intelligent judgment can be formed only with a knowledge of general physiology and with a simple and earnest desire to ascertain the truth as truth and not necessarily in its relations to the laws of physics and mechanics. The laws of inorganic Nature usually are definite and undisputed. Physiologists may use such laws and the facts which correspond to them in their applications to the animal functions; but observations in regard to the processes in animated Nature are not so fixed and definite. Physicists, chemists and mechanicians often work in the field of physiology; but they generally remain physicists, chemists or mechanicians; and they often take from physiology upon authority that only which suits their theories of what physiology should be, opposite observations to the contrary notwithstanding.

The question of the source of muscular power is not necessarily one of chemistry, physics or mechanics. Reasoning first upon what is known of the development, nutrition and disassimilation of muscular tissue, the endeavor should be to ascertain what are the phenomena which attend the exercise of muscular power. If any definite experimental facts can be arrived at by this method, then the heat-value and the force-value of food may be considered. No positive and stable doctrine can be established by assuming that the equivalents of heat and force ascertained by treating food as inorganic matter are to be rigorously applied to those mysterious changes which food and tissue undergo in the living organism. With such a method, there would be no necessity for what may be regarded as purely physiological observations; and the science of physiology would be reduced to a kind of materialism, in which the development of force would involve changes in matter from without instead of the matter of the organism itself.

Treating, as I shall endeavor to do, the question under consideration from a strictly physiological point of view, I shall first draw attention to what is known of the nutrition and development of muscular tissue, and then discuss certain observations upon the human subject during repose and during the exercise of muscular power, in which the physiological conditions appear to have been fulfilled.

NUTRITION AND DEVELOPMENT OF THE MUSCULAR SYSTEM

I do not propose, in this connection, to consider the original development of the muscular tissue, but shall endeavor to show how the nutrition of muscles may be promoted by diet and exercise so as to develop them to the maximum of size, strength and endurance. These ends are accomplished by what is known as "training."

The muscles of a person who takes little or no exercise usually are small, soft and of comparatively little power. The endurance, or capacity for prolonged muscular effort, is not great. The "wind" is deficient; that is, any unusual muscular effort is likely to produce temporary distress in breathing, and exhaustion. In healthy persons who habitually take but little exercise, coincident with a want of development of the muscular system, there generally is more or less fat in situations in which fat usually is deposited. The difficulty in breathing after unusual exertion is in part due to the deposition of fat in the omentum, which interferes with the free action of the diaphragm, in part to want of habit of vigorous action of the respiratory muscles generally, and to what may be rather indefinitely termed nervous exhaustion. In the exercise of running or fast walking, a person in this condition usually carries a certain weight of inert matter in the form of fat, which increases the demands on his muscular system. By a judicious process of training, however, the fat may be reduced to the minimum, the muscles, or working part, may be developed to the maximum, the general tone of the nervous system is improved, and the habit of efficient respiration is acquired, so that this process is carried on easily and in a way to supply the increased quantity of oxygen required during prolonged muscular effort.

When any particular set of muscles is persistently and systematically exercised, these muscles are developed out of proportion to the rest of the body, and they become capable of unusual power and effort. The general effects of such systematic exercise are the following: An increased consumption of oxygen, an increased elimination of carbonic acid, improved digestion, an increased demand for food and a diminished tendency to the accumulation of

fat, while the muscles exercised become harder and are sometimes increased in volume. Sometimes, when the muscles are originally large and soft, they are diminished in volume by exercise. During exercise there is an increased production of heat in the body, but the animal temperature is soon restored to the normal standard. During exercise, also, the general circulation becomes more active. The influence of exercise on the elimination of excrementitious matters, particularly urea, will be the main question for discussion and will be fully considered farther on.

The effects of exercise on particular muscles are the following: A local elevation of temperature, an increased supply of blood and a condition which is followed by increased activity of nutrition, with a diminution in the quantity of interstitial fat.

To bring the muscular system to the maximum of power and endurance, exercise must be carefully directed to that end, and the diet must be judiciously regulated. In the first place, the exercise should rarely be so severe or prolonged as to induce anything more than a temporary exhaustion, followed promptly by an agreeable reaction and a sense of fatigue readily relieved by repose. In training for a feat of strength involving a short and supreme effort, the daily exercise may culminate in an effort a little less severe than that which it is desired finally to attain. For feats of endurance the daily exercise should be less severe but more prolonged. A complete rest for twenty-four or forty-eight hours is desirable just before the feat to be accomplished is attempted, and the attempt should never be made while the digestive processes are in full operation.

The training diet recognized everywhere upon empirical and scientific grounds consists of the most nutritious meats, in such a form as to be easily digested, eggs, liquids in small quantity, with little or no fat, sugar, starchy matters, alcohol, tea, coffee, tobacco or articles which appear to retard disassimilation. The quantity of food of the kind indicated is not restricted except within the limits of good digestion. Nervous excitement of all kinds is to be avoided, the functions of the skin should be promoted and natural and sufficient sleep is indispensable. A man in

proper training is supposed to live for a time a purely physical life, with no end in view except the perfect development of his muscular system. He should experience a sense of high physical enjoyment in his course of training. How different is it with the poor, who are hard worked and insufficiently fed! The exertion in such instances is depressing and exhausting; the muscular system often becomes enfeebled; the deficiency in nourishment frequently induces an unnatural craving for alcohol and other stimulants; the system loses its power to resist disease; the work, instead of developing power of endurance, reduces the general tone of the system, and existence becomes almost a burden. On the other hand, a laboring-man, moderately worked and well fed, is frequently a very type of animal vigor.

It may now be inquired how the physiological exercise of the muscular system, with sufficient alimentation, affects the nutrition of the muscles themselves. Exercise undoubtedly increases within certain limits the power of the muscular system to assimilate the matters required for its proper nutrition and the full development of strength and endurance; but the exercise must be periodic and followed by sufficient intervals of repose and recuperation. These periods of repose and the assimilation of a proper amount of nutriment are recognized as absolutely necessary.

The question as to whether exercise actually consumes the muscular substance is the main one for consideration, the doctrine of some physiologists being that the consumption of matter in muscular work involves the elements of food and not the substance of the muscular tissue itself. I shall discuss this question rather briefly in this connection, leaving it to be answered more fully hereafter by experimental data. Take, as an illustration, the case of a man training for an athletic contest: The greatest part of the actual muscular work is done within two or three hours of the twenty-four; about eight hours are devoted to sleep, and the rest of the day is occupied in recreation, eating, etc. The fat of the body becomes so far reduced that it finally almost disappears from the omentum, the subcutaneous tissue and the interstices of the muscles. No sugar and but little starch and fat are

taken, the diet being almost exclusively nitrogenous. No proteids are discharged as such from the body, and the chief substance eliminated that contains nitrogen is urea. Taking the time actually employed in muscular work as about two hours, there is then a decided increase in the process of disassimilation, so far as this is to be measured by the elimination of carbonic acid, and the consumption of oxygen is proportionately increased; but if nitrogenous food is not taken in sufficient quantity, there is a sense of hunger, and the capacity for muscular work is diminished. The sense of hunger has its seat, not in the blood, but in the system at large, where the nervous system can be brought into action. All the food taken probably is digested and absorbed in six or eight hours, and the elimination of nitrogen by the kidneys is going on constantly.

It is almost impossible to imagine that the nitrogen eliminated in the urine during the long periods of the day when there is complete rest of the general muscular system represents only the work of the heart (which weighs but eight or ten ounces) and the action of the muscles in tranquil respiration, and that there is no disassimilation of the muscular tissue generally; and there is no evidence that the nitrogenous constituents of food are taken into the blood and are there directly changed into urea. It has been estimated by Sappey that the muscular system equals about two-fifths of the weight of the entire body in a well-proportioned man; * and in a man in high muscular training the proportion must be much larger. According to this estimate, the muscles of a man weighing one hundred and forty pounds would weigh about fifty-six pounds, and about fourteen pounds of blood circulate through these muscles constantly, the whole mass of blood passing through the heart about once a minute. With this constant passage of blood through the muscular tissue, it is probable that something more of an interchange takes place between the blood and the muscular substance than the mere consumption of oxygen and giving off of carbonic acid.

The large quantity of nitrogenous food taken during training is necessary in order to maintain the muscular

* Sappey, "Traité d'anatomie," Paris, 1868, tome ii., p. 6.

system at a certain standard of weight. If this is true, the muscles must be constantly losing substance by disassimilation and as constantly repairing themselves by matters appropriated from the blood. As the muscles constitute the largest part of the nitrogenous constituents of the body, it is reasonable to suppose that the excretion of urea, which is the chief nitrogenous excrementitious substance, represents more or less fully the activity of muscular disassimilation. In support of these views is the following fact, which has been long recognized:

For sake of illustration I suppose that a pugilist, weighing two hundred pounds, agrees to fight in three or six months at a weight of one hundred and sixty-five pounds or less, at which latter weight, he judges from experience that he can maintain his strength and endurance. He puts himself in "training" and first eliminates his fat by exercise, sweating and a nitrogenous diet, which may easily be done. When this has been accomplished, although he has no fat, he weighs one hundred and seventy-five pounds, or is ten pounds "over-weight." The object now is to reduce the weight to the prescribed standard, and in this process to weaken the muscular force and endurance as little as possible; but it is evident that this can not be done without reducing the weight of the muscles. To accomplish this, the usual course is to exercise violently and to promote profuse sweating, at the same time restricting the ingestion of liquids as much as possible. In this way, as the loss by perspiration is not supplied, the weight of the body must diminish. The deficient quantity of water seems to prevent the full supply of reparative matter to the muscles, while it does not interfere so much with their disassimilation. At all events, it is evident that the loss of weight involves the muscles almost exclusively; and this probably is due primarily to the excessive exercise. With this violent exercise, the muscular system might be reduced in weight by restricting the quantity of nitrogenous food; but experience has shown that this course involves much greater loss of strength than the reduction of weight by restricting the quantity of liquids.

Practically, it has been found difficult to keep the weight of the body much below the normal standard for any considerable length of time; and an increase in the

quantity of liquids taken will add several pounds to the weight in the course of a few hours. Such reduction of weight, however, has its limit; and it has very often occurred that men have miscalculated the effects of this severe course of training, and although they have gone into the ring at the prescribed weight, and apparently in very "fine condition," they have been utterly incapable of making a contest.

Some persons, whose muscles are small and who have no tendency to accumulation of fat, increase very considerably in weight under an ordinary course of training.

A steam engine is not "trained" to accomplish a certain amount of work. A machine of this kind is perfected in all of its parts and is so constructed as to be of sufficient strength to overcome such resistance as it is likely to meet. It is simply an apparatus for transforming heat furnished by fuel into useful force, and it is nothing without fuel. Man, on the other hand, is a living being, developed from a fecundated ovum of microscopic size, by a process which physiologists have hardly begun to comprehend. In his growth, the various tissues and organs have the power of assimilating materials for development when presented in an appropriate form and under proper conditions. There is no reason to suppose that the nature of this process of nutrition radically changes when the being reaches adult life, and there is no reasonable argument in favor of such a view. A man may take a certain quantity and kind of food, and still, without training, be able to perform only a certain amount of work. After proper training, with precisely the same food he can develop greatly increased power. His span of life is definitely fixed; and no degree of care can prevent the retrograde organic changes which result in death.

Assuming that a proper system of training is essential to perfect development of the machinery of the muscular system, the simple question is whether, in the perfected muscular system of the adult, force is generated by changes of the muscular substance or whether the force is due to the direct transformation of constituents of food. In other words, is the muscular substance an apparatus for transforming the force locked up in food into power, or are the muscles themselves consumed, food being used

for their repair? These questions may be solved by little more than a single experimental line of inquiry: Does physiological exercise of the muscular system increase the elimination of nitrogenous excrementitious matters?

RELATIONS OF THE MUSCULAR SYSTEM TO THE ELIMINATION OF NITROGEN

There seems to be good ground for supposing that the elimination of nitrogen is closely related to the physiological wear of muscular tissue, for several reasons. The muscular system may be, under certain conditions, the only part of the body that is materially affected by exercise. In a man of ordinary development, the muscular system constitutes at least two-fifths of the total weight. Fat may disappear almost entirely from the body and the food may be restricted to nitrogenous matters, without disturbing nutrition. These matters are never discharged from the body as proteids, but the nitrogen is eliminated chiefly in the urea. Under such conditions, and with a varying amount of exercise, it is the muscular system only which presents any considerable changes in weight.

Supposing the fat of the body to be reduced to its minimum—and it usually constitutes but about one-twentieth of the total weight—there are no other parts that can be affected by exercise; for there is no reason to suppose that the nervous system, the abdominal, thoracic or pelvic viscera, the skin, bones or tendons present any immediate changes in weight as the result of muscular exertion. Take the case of Weston, the pedestrian, who was under my observation in 1870 and who weighed a little more than one hundred and nineteen pounds just before he began a walk of five consecutive days. He must have had at least forty-eight pounds of muscular tissue, and he was reduced in weight, during a walk of two hundred and seventy-seven miles in four consecutive days, to one hundred and fourteen pounds.* During this time he consumed probably five pounds of muscular tissue which could not be repaired by food, or about ten per cent. of the total weight of muscle. It might be assumed that he consumed this amount of muscular substance because the food

* This was the greatest loss of weight observed at any time during the walk of five days.

taken was insufficient to produce the force exerted; but it is more reasonable to suppose that he lost muscular weight because the food could not repair the excessive waste engendered by the extraordinary amount of work accomplished. However this may be, correct views must rest upon the experimental answer to the question whether or not muscular exercise increases the elimination of nitrogen from the body.

In discussing the various experiments that have been made in respect to the influence of muscular exercise upon the elimination of nitrogen, I shall confine myself to those made upon the human subject. It is evident that such observations must be made when the subjects of experiment are under strictly physiological conditions, especially as regards alimentation and general nutrition. It is evident, also, that the direct influence of food upon the excretion of nitrogen must not be neglected. To meet this latter requirement, it would seem proper, in estimating the quantities of nitrogen discharged under various conditions, to calculate the proportion of nitrogen discharged to the nitrogen of food. This, however, has not been done in all of the experiments which I shall discuss.

EXPERIMENTS OF LIEBIG, LEHMANN, FICK AND WISLICENUS AND PARKES

The experiments of Fick and Wislicenus, published in 1866, are thought by some to have revolutionized the ideas of physiologists in regard to the significance of the excretion of nitrogen. Before that time, the theory of Liebig, which is expressed in the following quotations, was generally adopted:

> "Boiled and roasted flesh is converted at once into blood; while the uric acid and urea are derived from the metamorphosed tissues. The quantity of these products increases with the rapidity of the transformation in a given time, but bears no proportion to the amount of food taken in the same period. In a starving man, who is in any way compelled to undergo severe and continued exertion, more urea is secreted than in the most highly-fed individual if in a state of rest."

The last statement contained in the above quotation is very broad, and it does not appear to be made on the basis of direct experiment.

Again, Liebig makes the general statement that "the amount of tissue metamorphosis in a given time may be measured by the nitrogen in the urine." *

The doctrine thus enunciated by Liebig was modified a few years later by the researches of Lehmann, who showed, by observations upon his own person, that, other conditions being equal, the character and quantity of food modified very greatly the elimination of urea, as is seen by the following quotation:

> "My experiments show that the amount of urea which is excreted is extremely dependent on the nature of the food which has been previously taken. On a purely animal diet, or on food very rich in nitrogen, there were often two-fifths more urea excreted than on a mixed diet; while, on a mixed diet, there was almost one-third more than on a purely vegetable diet; while, finally, on a non-nitrogenous diet, the amount of urea was less than half the quantity excreted during an ordinary mixed diet."

Lehmann further states, however, that under a uniform diet the elimination of urea is increased by muscular exercise.†

In 1866 Fick and Wislicenus published their account of experiments made in ascending one of the Alpine peaks, the Faulhorn, about 6,500 feet high. These experiments were undertaken with the view of showing that severe and prolonged muscular effort could be accomplished upon a non-nitrogenous diet. The two experimenters took no proteid food from midday on August 29 until seven P. M. on August 30. The experiments proper began on the evening of the 29th, at a quarter-past six P. M., by a complete evacuation of the bladder. The urine from this time until ten minutes past five on the morning of the 30th (about eleven hours) was collected, and called the "night urine." The ascent began at ten minutes past five and occupied eight hours and ten minutes. The urine passed during this period was collected as "work urine." The urine for five hours and forty minutes after the ascent was collected as "after-work urine." The urine from seven P. M., August 30, until half-past five A. M., August 31, was collected and designated as "night urine." The results of the examinations of these specimens in the two persons

* Liebig, "Animal Chemistry," London, 1843, pp. 138 and 245.

† Lehmann, "Physiological Chemistry," Philadelphia, 1855, vol. i., p. 150.

were nearly identical. The following is the estimate of the elimination of nitrogen per hour during these periods:

	Fick.	Wislicenus.
During the night, 29th to 30th,	0.63 gramme.	0.61 gramme.
During the time of work,	0.41 "	0.39 "
During rest after work,	0.40 "	0.40 "
During the night, 30th to 31st,	0.45 "	0.51 "

From these results Fick and Wislicenus conclude that muscular exercise does not necessarily increase the elimination of nitrogen; that the substance of the muscle itself is consumed in insignificant quantity; and that the muscular system is a machine, consuming, in its work, not its own substance, but fuel which is supplied by the food. The most efficient fuel Fick and Wislicenus consider to be non-nitrogenous food; the results of its consumption being force (or work), heat and carbonic acid. They adopt the view "that the substances, by the burning of which force is generated in the muscles, are not the albuminous constituents of the tissues, but non-nitrogenous substances, either as fats or hydrates of carbon."

"We might express this doctrine by the following simile: A bundle of muscle-fibres is a kind of machine consisting of albuminous material, just as a steam engine is made of steel, iron, brass, etc. Now, as in the steam engine coal is burnt in order to produce force, so, in the muscular machine, fats or hydrates of carbon are burnt for the same purpose. And in the same manner as the constructive material of the steam engine (iron, etc.) is worn away and oxidized, the constructive material of the muscle is worn away, and this wearing away is the source of the nitrogenous constituents of the urine. This theory explains why, during muscular exertion, the excretion of the nitrogenous constituents of the urine is little or not at all increased, while that of the carbonic acid is enormously augmented; for, in a steam engine, moderately fired and ready for use, the oxidation of iron, etc., would go on tolerably equably, and would not be much increased by the more rapid firing necessary for working, but much more coal would be burnt when it was at work than when it was standing idle." *

The question under consideration is not materially advanced or modified by the experiments of Frankland † or of Haughton,‡ who adopt fully the views of Fick and Wislicenus.

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* Fick and Wislicenus, "On the Origin of Muscular Power."—"London Edinburgh and Dublin Phil. Mag.," London, January to June, 1866, vol. xxxi., pp. 492 to 501.

† Frankland, "On the Origin of Muscular Power."—"London, Edinburgh and Dublin Phil. Mag.," London, July to December, 1866, vol. xxxii., p. 182 *et seq.* ‡ Haughton, "The Lancet," London, August 15, 22, and 29, 1868.

In 1867 experiments were made by the late Dr. Parkes upon two soldiers, with the view of controlling the experiments of Fick and Wislicenus by observations upon a more extended scale.* These experiments were continued for a period of eighteen days, and they certainly seem to show an increase in the elimination of urea attributable to muscular exercise. The extraordinary exercise taken was a walk of 23.7 miles on one day, and 32.78 miles on the day following. During these two days, on an exclusively non-nitrogenous diet, the elimination of nitrogen was slightly increased over a period of two days of rest, also on a non-nitrogenous diet. In an analysis of a recent course of lectures delivered by Dr. Parkes at the College of Physicians, London, it appears that he is disposed to take a view of the subject between the two extremes; viz., that the muscular system is able to accomplish work by the consumption of non-nitrogenous food; that exercise does, however, slightly increase the elimination of urea, and that during exercise, a small portion of the muscular substance is consumed; but he holds that the variations in the quantity of nitrogen eliminated are almost entirely dependent upon the quantity of nitrogen contained in the food.†

In 1870 Liebig published an article in which he again discussed the question from his own point of view. He analyzed very fully the experiments of Parkes and found in the results fresh testimony in favor of his view that the increase in the elimination of nitrogen as a consequence of muscular exercise is not limited to the period of exertion but continues for some time after.‡ On the other hand, Voit published, also in 1870, an elaborate paper reviewing the publications on this question that had appeared for the past twenty-five years.# Neither of these papers, however, has added to the sum of physiological knowledge by the contribution of new experimental facts; but they are interesting as expressing the arguments upon

* Parkes, "On the Elimination of Nitrogen by the Kidneys and Intestines, during Rest and Exercise, on a Diet without Nitrogen."—"Proceedings of the Royal Society," London, 1867, vol. xv., No. 89, p. 339 *et seq.*

† "Medical Times and Gazette," London, March 15, 1871, p. 348.

‡ Liebig, "The Source of Muscular Power."—"Pharmaceutical Journal and Transactions," London, 1870, third series, part ii., p. 161, and part iii., pp. 181, 201 and 222.

"Zeitschrift für Biologie," München, 1870, Bd. vi., S. 305 *et seq.*

two opposite sides, and they illustrate the necessity of new observations in which some of the important omissions in the experiments hitherto made may be supplied.

A serious objection, in my opinion, to the observations of Fick and Wislicenus, which constitute the starting-point of the new theory of the source of muscular power, is the fact that the experiments were made when the system was not under physiological conditions.

For a period of thirty-one hours these two experimenters took no proteid food; and within that time they were eight hours and ten minutes in making an ascent of 6,500 feet. It can not be assumed that they were in a proper condition, as regards alimentation, to perform this work; and it is illogical to conclude, as the result of such observations, "that the substances, by the burning of which force is generated in the muscles, are not the albuminous constituents of the tissues, but non-nitrogenous substances, either as fats or hydrates of carbon." No attempt was made to measure the carbonic acid eliminated or the part of the assumed changes in the non-nitrogenous matters consumed which was concerned in the production of heat; and no account was taken of the variations in the weight of the body. Again, it is well known that the change of the normal diet to a regimen of non-nitrogenous matters alone of itself diminishes very largely the excretion of nitrogen.

In addition to what I have already quoted from Lehmann, he states that "there is as much urea in the urine after a prolonged absence from all food (after a rigid fast of twenty-four hours) as after the use of perfectly non-nitrogenous food." Taking the results of the experiments upon Fick—and those upon Wislicenus are almost identical—for about eleven hours just preceding the ascent, the elimination of nitrogen per hour was 0.63 of a gramme. During this time and for about six hours before, no nitrogenous food was taken. During the succeeding eight hours and ten minutes which were occupied in the ascent, the hourly elimination of nitrogen was 0.41 of a gramme, a reduction of about one-third. During five hours and forty minutes after the work, still without nitrogenous food, there was a further, but a very slight reduction in the nitrogen eliminated, the hourly quantity being 0.40 of a gramme. During the succeeding period of ten hours and thirty minutes,

with a return to nitrogenous food, there was an increase in the nitrogen eliminated, amounting to a little more than twelve per cent. above the lowest point, the hourly quantity being 0.45 of a gramme. Lehmann has shown that irrespective of muscular exercise, the elimination of nitrogen is diminished more than one-half by a non-nitrogenous diet. This would fully account for the diminution observed by Fick and Wislicenus.

Viewed physiologically, without reference to any particular theory of the source of muscular power, the experiments of Fick and Wislicenus seem to have no great value. The only way in which they could have had any bearing upon the question under consideration would have been by comparing them with observations under the same conditions of diet, but with no muscular work. If Fick and Wislicenus had shown that the excretion of nitrogen without muscular exercise was diminished to a certain degree by non-nitrogenous diet, and that with work, under precisely the same diet, the elimination was diminished to a greater degree than it had been without work, this would have shown that "muscular exercise does not necessarily increase the elimination of nitrogen." Without such observations on the influence of a non-nitrogenous diet without work, I fail to understand how physiologists can accept the doctrine of Fick and Wislicenus, except on the assumption of the correctness of a theory which rests entirely upon the basis of their experiments. Such methods of reasoning would certainly tend to retard advance in positive knowledge.

Dr. Pavy, in his observations upon this subject, supplies the omission made by Fick and Wislicenus by experimental facts which really overthrow their theory.* Dr. Pavy gives an illustration where a person under ordinary conditions as regards exercise passed from a mixed to a purely non-nitrogenous diet. "During seventeen hours of May 5, while upon mixed food, the urea eliminated represented 197 grains of nitrogen." (This equals 11.59 grains per hour.) "During twenty-three hours of May 6, when only non-nitrogenous food, consisting of arrowroot, sugar, and butter, was taken, the nitrogen in the urea

* "The Lancet," London, December 23, 1876, p. 888.

voided amounted to 187 grains" (this equals 8.13 grains per hour); "and for the twenty-four hours of the following day, the diet still consisting of non-nitrogenous food, it amounted to 136 grains." (This equals 5.66 grains per hour.) Under uniform conditions of exercise, then, non-nitrogenous food diminished the nitrogen excreted for the first twenty-three hours about one-third below the standard with an ordinary mixed diet. The non-nitrogenous diet continued through the succeeding twenty-four hours diminished the nitrogen excreted to about one-half of the normal standard. These results nearly coincide with those obtained by Lehmann.

The observations upon Fick during about eleven hours of a non-nitrogenous diet without work gave 0.63 of a gramme of nitrogen per hour. This period may be taken as corresponding with the first period of twenty-three hours in Dr. Pavy's observations, in which the hourly elimination of nitrogen was 8.13 grains, as the nitrogen in Fick's observation was undoubtedly reduced below the standard under a mixed diet. During the eight hours and ten minutes of work in Fick's observations, still with a non-nitrogenous diet, the nitrogen was reduced from 0.63 of a gramme to 0.41 of a gramme per hour, or about one-third. During the twenty-four hours of Dr. Pavy's observation, still with a non-nitrogenous diet but with no variation in exercise, the nitrogen excreted hourly was reduced from 8.13 grains to 5.66 grains, or about one-third, nearly the same as in the observations upon Fick. At the end of the time calculated by Fick the non-nitrogenous food had been taken for twenty-five hours and twenty minutes; viz., from noon on August 29 to twenty minutes past one on August 30. At the end of the time noted for Dr. Pavy the non-nitrogenous food had been taken for forty-seven hours, with no variation in the exercise. These observations, therefore, seem to show that the diminished excretion of nitrogen under a purely non-nitrogenous diet, which is certainly not a physiological condition, depends entirely upon the food.

The observations of Parkes, which were made "on a diet without nitrogen," are open to precisely the same objections and invite the same criticism as that which I have made of the experiments of Fick and Wislicenus.

EXPERIMENTS OF DR. PAVY

The experiments of Dr. Pavy upon Weston, the pedestrian, in 1876,* were made upon the same person, by the same method and under the same conditions as those which I made in 1870. The plan of my own experiments, which was adopted by Dr. Pavy in his observations, was to measure the proportion of nitrogen eliminated to the nitrogen of food during rest and during extraordinary muscular exertion, with the view of ascertaining the influence of exercise upon nutrition and disassimilation. Dr. Pavy corrected some errors in method and calculation in my experiments, which I willingly accept and shall refer to farther on. I reserve, however, the consideration of my own experiments for the last, because it is from them that I shall make the deductions which will conclude this essay. Still, I shall compare Dr. Pavy's observations with mine in the course of the discussion.

The subjects of Dr. Pavy's experiments were the following:

I. A walk by Perkins, a pedestrian, of sixty-five and one-half miles in twenty-four hours.

II. A period of twenty-four hours of rest following the walk, after an interval of several days.

III. Two periods of twenty-four hours each, in which Weston, a pedestrian, walked, during the first twenty-four hours, one hundred miles, and during the second twenty-four hours, eighty and one-half miles.

IV. A period of twenty-four hours of rest immediately preceding a walk by Weston of seventy-five hours.

V. Three periods of twenty-four hours each, in which Weston walked, during the first period, one hundred and four miles; during the second period, seventy-six miles; and during the third period, eighty-three miles.

VI. A period of twenty-four hours of rest immediately succeeding Weston's walk of seventy-five hours.

VII. Six periods of twenty-four hours each, immediately preceding a walk by Weston of six days.

VIII. Six periods of twenty-four hours each, in which Weston walked, during the first period, ninety-six miles;

* "The Lancet," London, February 26, March 4, 11, 18, 25, November 25, December 9, 16, 23, 1876, and January 13, 1877.

during the second period, seventy-seven miles; during the third period, seventy and one-half miles; during the fourth period, seventy-six and one-half miles; during the fifth period, sixty-seven miles; and during the sixth period, sixty-three miles, making a walk of four hundred and fifty miles in six consecutive days.

IX. Six periods of rest of twenty-four hours each, immediately succeeding Weston's walk of six days.

In these observations the number of miles walked is given for each period, except for the periods of rest, when it is assumed that little or no exercise was taken.*

The body-weight is given, except for the rest-periods before and after Weston's seventy-five hours' walk, the six periods of twenty-four hours each, immediately succeeding Weston's six days' walk and Perkins's period of rest. For the six days preceding Weston's six days' walk, the weights are given as "without clothing," and they can not be compared with the weights for the six days' walk, which are given as "in costume."

The nitrogen of food is given for all the periods except for the six days following Weston's six days' walk. It is not stated precisely how the estimates of the quantities of the different articles of food were made, but as these are so important, I must assume that they are approximately correct. At least it is fair to suppose that the errors in these estimates, if any errors exist, are uniform for all the different periods and therefore that they do not affect the comparative results.

In my own observations each separate article of food was placed upon a different plate which was weighed before and after eating, the difference in weight giving the actual quantity consumed. This would eliminate bone and matter not actually eaten. I am led to call attention to this, for the reason that the average quantity of nitrogen consumed daily by both Perkins and Weston for twelve days of walking was 556.79 grains. The average daily consumption of nitrogen by Weston, observed by me, for

* For the six days' period of rest previous to the six days' walk, the following note is made by Dr. Pavy: "During the first two days Weston kept entirely to the house, and during the last four the amount of walking did not reach twenty miles. The results, therefore, will represent a state of comparative rest."—"The Lancet," March 11, 1876, p. 392.

five days of walking, was 234.76 grains, less than one-half that noted by Dr. Pavy; and the daily average for ten days of rest was 390.18 grains. Dr. Pavy, however, notes that the food taken was much greater in quantity in his experiments.* In all of my experiments Weston took what he wished, both as regards quantity and kind of food. It seems to me to have been an important omission on the

* After I had seen the first detailed account of Dr. Pavy's observations, which was published in "The Lancet" several months before the publication of the tabulated results and the conclusions, I made a rough estimate of the nitrogen of the food, using the proportions which I had taken for my observations upon Weston in 1870. According to this estimate, the average amount of nitrogen consumed daily by both Perkins and Weston for twelve days of walking was 460.05 grains. Dr. Pavy's estimate, published later, was very much higher, the daily average for the same periods being 556.79 grains. After Dr. Pavy had published his tabulated results and conclusions, I made a calculation of the nitrogen of food for the second twenty-four hours of the six days' walk, which gave, according to Dr. Pavy's estimate the greatest quantity of nitrogen; viz., 826.43 grains. I endeavored to estimate the nitrogen according to Dr. Pavy's method, but I could not make more than 781.73 grains for the twenty-four hours. This is the only day for which I have endeavored to verify Dr. Pavy's calculations, and I can not see why our results should differ so much. The quantities of food for this day are given in "The Lancet," March 18, 1876, page 430; and the estimates of the proportion of nitrogen in the various articles of food are in "The Lancet," November 26, 1876, page 472. The following is my own estimate, according to Dr. Pavy's figures, for that day.

SECOND TWENTY-FOUR HOURS OF WESTON'S SIX DAYS' WALK

Quantities of Food.	Nitrogen of Food.
Cooked meat, 1 lb. 6½ oz. (15.31 grs. of nitrogen per oz.).....	344.475 grains.
Three yolks of eggs (6.45 grs. of nitrogen in each)...........	19.350 "
Four poached eggs (16.62 grs. of nitrogen in each)...........	66.480 "
Jelly, 1 pt. 3 oz. (2.62 grs. of nitrogen per fluid oz.)..........	49.780 "
Beef-tea from fresh meat, ½ pt. (1.55 gr. of nitrogen per fluid oz.)...	12.400 "
Liebig's extract, 4¼ oz. by weight, taken as beef-tea (37.73 grs. of nitrogen per oz.).................................	160.350 "
Brand's essence of beef, 1¼ oz. by weight (4.37 grs. of nitrogen per oz.)..	5.462 "
Milk, 1⅓ pt. (2.22 grs. of nitrogen per oz.)..................	47.360 "
Oatmeal, 3½ oz. in the form of gruel (8.53 grs. of nitrogen per oz.)...	29.855 "
Bread, 3 oz. in the form of dry toast (4.68 grs. of nitrogen per oz.)...	14.040 "
Bread, spread with butter, 2½ oz. (1.40 gr. of nitrogen allowed for butter)..	13.100 "
Potatoes, 3 oz. (1.44 gr. of nitrogen per oz.)................	4.320 "
Coffee, 2¾ oz. (I assume that this is coffee roasted and ground, and that 1 oz. gives 8 oz. of infusion, containing 0.481 gr. of nitrogen per fluid oz.)..............................	10.582 "
Tea, 1 oz. (I estimate 48 oz. of infusion, containing 0.087 gr. of nitrogen per fluid oz.)............................	4.176 "
Sugar, ¼ lb.; grapes, ¾ lb.; 1½ orange (no nitrogen).........	......
Total nitrogen in twenty-four hours.............	781.730 grains.

part of Dr. Pavy that he did not note the weights of the body and the quantities of nitrogen taken during the six days following the six days' walk, when the system was recuperating after the great exertion which had been made. The nitrogen of food was estimated by Dr. Pavy by essentially the same methods as those employed by me, using mainly the calculations of Payen.

To represent the nitrogen excreted, Dr. Pavy estimated the nitrogen contained in the urea and uric acid for each period in all of his observations, while I estimated the nitrogen contained in the urea and feces. The excretion of uric acid was found to be much greater in Dr. Pavy's observations than in mine. This difference, although considerable, is not so great as to affect the conclusions in either case. Dr. Pavy objects to my analysis for uric acid on the ground that I used nitric acid for its precipitation instead of hydrochloric acid, and that the time allowed for the uric acid to separate was not sufficiently long. His experiments upon this point show conclusively that he is correct. Still, the quantities obtained by me do not appear to be small as compared with the estimates given by most authorities, and I merely gave the processes employed and the results obtained by the chemists, having had nothing to do personally with the analyses.

To obtain all of the nitrogen of the urine, Dr. Pavy might have estimated the nitrogen of the hippuric acid and of the creatin and creatinin, which would have made a difference of three or four grains of nitrogen for each day. While I can not regard this omission as important, I must contend that the nitrogen of the feces should have been estimated. In my experiments the daily average of nitrogen of feces for the five days before the walk was 21.91 grains, for the five days of the walk, 24.32 grains, and for the five days after the walk, 33.99 grains. As Dr. Pavy states, it may not be assumed that the nitrogen of the feces resulted from any waste of tissue; still, in calculating accurately the ingress and the egress of nitrogen, the feces should be taken into account, and the nitrogen of the feces should be deducted from the nitrogen of food, as it could not be part of the nitrogen assimilated. But this, even if it is regarded as an error in Dr. Pavy's experiments, is not important.

In the table on pages 28 and 29, which gives the main results of Dr. Pavy's observations, I have myself calculated for each period the proportion of nitrogen excreted in the urea and uric acid to the nitrogen of food.

I shall now endeavor to follow the process of reasoning by which Dr. Pavy draws his conclusions from the facts contained in the table just given. Dr. Pavy at the outset makes the following statement, the accuracy of the first part of which is sufficiently evident:

"Under any way of looking at the figures, it is evident that we have an increased elimination of nitrogen to deal with during the days of walking, which is not to be accounted for by the nitrogen ingested. We can only, therefore, refer this increase to the effect of the exercise; but is it the result—is it the expression of the action which has given rise to the power evolved? This is the question that presents itself for solution, and I will attempt to solve it by ascertaining whether the force liberated by the oxidation of muscular tissue corresponding with the nitrogen discharged is sufficient to account for the work performed."

Dr. Pavy, as is seen by the above quotation, does not fail to see that the increased elimination of nitrogen is due directly to the excessive exercise, the simple proposition which I attempted to prove by my observations in 1870. This being admitted, the question which seems to occur to his mind is how this fact can be made to accord with the idea presented as a proposition preliminary to his deductions, which is the following:

"The food of animals contains force in a latent state. Properly regarded, food must be looked upon, not simply as so much ponderable matter, but as matter holding locked-up force. By the play of changes occurring in the body the force becomes liberated, and is manifested as muscular action, assimilative, secretory, or nutritive action, heat, etc."

He assumes the fact, which is probably correct so far as can be determined by experiments out of the body, that there is a fixed dynamic or mechanical work-value for a certain quantity of albuminous matter. By means of the calorimeter, Prof. Frankland has determined the quantity of heat evolved by the combustion of such matter, and by the formula of Joule, the equivalent of working-power of this heat may readily be calculated. These calculations are taken by Dr. Pavy as the basis for his own reasoning.*

* "The Lancet," London, December 16th, p. 849.

TABLE OF RESULTS OBTAINED FOR DAYS OF WALKING AND FOR DAYS OF REST

Pavy, "Effect of Prolonged Muscular Exercise upon the Urine in Relation to the Source of Muscular Power."—("The Lancet," London, December 9, 1876, pp. 816, 817.)

	Perkins' 24 Hours' Walk.	Perkins' Day of Rest.	First 24 Hours of Weston's 48 Hours' Walk.	Second 24 Hours of Weston's 48 Hours' Walk.	Twenty-four Hours preceding Weston's 75 Hours' Walk.	First 24 Hours of Weston's 75 Hours' Walk.	Second 24 Hours of Weston's 75 Hours' Walk.	Third 24 Hours of Weston's 75 Hours' Walk.
Body-Weight* (with Clothing)........	137 lbs.	Not given.	137¾ lbs.	133 lbs. at close of walk.	Not obtained.	137 lbs.	135 lbs.	134 lbs.
Miles walked......	65.5	....	100	80.5	....	104	76	83
Nitrogen of Food..	315.50 grs.	357.68 grs.	65.68 grs.	161.72 grs.	523.11 grs.	522.42 grs.	871.92 grs.	713.96 grs.
Nitrogen of Urea and Uric Acid...	600.63 "	273.90 "	550.95 "	461.57 "	303.19 "	496.21 "	563.80 "	533.11 "
Per cent. of Nitrogen excreted † in Urea and Uric Acid...	190.37	76.58	838.84	285.41	57.96	94.98	64.66	74.67

	Twenty-four Hours Rest Period after Weston's 75 Hours' Walk.	First 24 Hours of Six Day Period prior to Weston's 6 Days' Walk.	Second 24 Hours of Six Day Period prior to Weston's 6 Days' Walk.	Third 24 Hours of Six Day Period prior to Weston's 6 Days' Walk.	Fourth 24 Hours of Six Day Period prior to Weston's 6 Days' Walk.	Fifth 24 Hours of Six Day Period prior to Weston's 6 Days' Walk.	Sixth 24 Hours of Six Day Period prior to Weston's 6 Days' Walk.	First 24 Hours of Weston's 6 Days' Walk.
Body-Weight (with Clothing)........	Not given.	(?)	(?)	(?)	(?)	(?)	(?)	$134\frac{13}{16}$ lbs.
Miles walked......	....	....	....	....	....	....	....	96
Nitrogen of Food..	645.11 grs.	378.29 grs.	451.14 grs.	472.29 grs.	539.95 grs.	441.15 grs.	582.80 grs.	491.80 grs.
Nitrogen of Urea and Uric Acid...	234.91 "	292.70 "	301.75 "	231.54 "	363.71 "	342.59 "	387.17 "	524.59 "
Per cent. of Nitrogen excreted in Urea and Uric Acid...	36.41	77.37	66.88	49.02	67.36	77.65	66.43	106.67

* See foot-note (*) on p. 29.

† See foot-note (†) on p. 29.

TABLE OF RESULTS OBTAINED FOR DAYS OF WALKING AND FOR DAYS OF REST—(Continued)

	Second 24 Hours of Weston's 6 Days' Walk.	Third 24 Hours of Weston's 6 Days' Walk.	Fourth 24 Hours of Weston's 6 Days' Walk.	Fifth 24 Hours of Weston's 6 Days' Walk.	Sixth 24 Hours of Weston's 6 Days' Walk.	First 24 Hours after Weston's 6 Days' Walk.	Second 24 Hours after Weston's 6 Days' Walk.
Body-Weight * (with Clothing)...	$132\frac{13}{16}$ lbs.	$132\frac{1}{16}$ lbs.	$132\frac{9}{16}$ lbs.	$131\frac{1}{8}$ lbs.	$130\frac{5}{16}$ lbs.	Not given.	Not given.
Miles walked..................	77	70.5	76.5	67	63	....	....
Nitrogen of Food	826.43 grs.	759.15 grs.	547.57 grs.	790.78 grs.	614.61 grs.	Not given.	Not given.
Nitrogen of Urea and Uric Acid .	582.42 "	600.29 "	503.21 "	450.06 "	468.70 "	384.40 grs.	238.39 grs.
Per cent. of Nitrogen excreted † in Urea and Uric Acid........	70.47	79.07	91.90	56.91	76.26	Can not be estimated.	Can not be estimated.

	Third 24 Hours after Weston's 6 Days' Walk.	Fourth 24 Hours after Weston's 6 Days' Walk.	Fifth 24 Hours after Weston's 6 Days' Walk.	Sixth 24 Hours after Weston's 6 Days' Walk.	Daily Average for the 15 Days of Rest.	Daily average for the 12 Days of Walking.
Body-Weight (with Clothing).....	Not given.	Not given.	Not given.	Not given.	....	....
Miles walked..................	....	....	....	....	....	79.91
Nitrogen of Food...............	Not given.	Not given.	Not given.	Not given.	487.94 grs. (for 9 days).	556.79 grs.
Nitrogen of Urea and Uric Acid..	381.22 grs.	278.46 grs.	299.19 grs.	268.17 grs.	303.49 grs. (for 9 days). 305.42 grs. (for 15 days).	527.96 "
Per cent. of Nitrogen excreted in Urea and Uric Acid..........	Can not be estimated.	Can not be estimated.	Can not be estimated.	Can not be estimated.	62.20 (for 9 days); can not be estimated for 15 days.	94.82

* For the six days before the six days' walk the weight is given as "without clothing," and it can not be compared with the weights of other days, which are given as "in costume."

† The figures in this line were calculated by myself from the results obtained by Dr. Pavy.

While all this is sufficiently definite and positive, when the application is made to the muscular work performed by the subjects of his experiments the element of inaccuracy seems to be very great. By using the methods of Frankland and Joule, it can be shown that the oxidation of the nitrogenous matter represented by the nitrogen eliminated from the body would, if such oxidation were simple combustion out of the body, produce a definite amount of heat, which would be equal to a certain number of foot-tons of work. But in the actual experiments on Perkins and Weston, the definite results are to be found in the amount of work actually performed. These men walked a certain number of miles; and this is the main experimental fact. To bring this fact into the only form in which it can be compared with the calculations of the force-value of the albuminous matter represented by the nitrogen excreted, it is necessary to reduce the miles walked to foot-pounds or foot-tons of work. The following statement of the formula by which this is done shows an inaccuracy which seems fatal to the calculations upon which Dr. Pavy's views are based:

> "According to Prof. Haughton, the force expended in walking on level ground may be estimated as equal to that required to raise one-twentieth of the weight of the body through the distance traversed. The number of miles walked being brought into feet, multiplying by one-twentieth of the weight of the body represented in pounds, will give the work in foot-pounds; but as so extensive a series of figures has here to be dealt with, it is convenient to reduce the result to foot-tons."

To illustrate this inaccuracy, I have only to present the following calculations for Weston's six days' walk made under Dr. Pavy's observation, and for the five days' walk observed by myself in 1870:

During the six days, according to Dr. Pavy's calculations, Weston walked four hundred and fifty miles, equivalent, according to the formula of Haughton, to work represented by 7,026.06 foot-tons.* This was the work actually accomplished. During this time the total nitrogen of food taken was 4,030.34 grains. The loss of weight of the body during that time was four and one-half pounds, or 31,500 grains. Payen's calculations give the propor-

* "The Lancet," London, December 16, 1876, p. 849.

tion of nitrogen in fresh beef without bones as three parts in one hundred.* This formula, applied to the muscular tissue lost during the walk, assuming that the loss of weight was due entirely to loss of muscular substance, gives for nitrogen that would represent the loss in the weight of the body, 945 grains, which added to the nitrogen of the food gives a total of 4,975.34 grains. According to Dr. Pavy's estimate that one grain of nitrogen oxidized represents 2.4355 foot-tons of work, the force contained in the nitrogen of food and the nitrogen of muscular tissue wasted would amount to 12,117.44 foot-tons. This, however, is the total work represented by the nitrogen of food and of the muscular tissue lost; and from this must be deducted the force required for "nervous action, assimilative, secretory, or nutritive action, heat, etc." This latter, as calculated by Dr. Pavy, is represented by the nitrogen excreted during the days when no muscular work was performed. To accord with my first calculation, this must be represented by the nitrogen of food for these days of rest. Restricting this calculation to the case of Weston, and taking his six days of rest prior to the walk (for the nitrogen of food is not given for the six days after the walk) I find that the nitrogen of food for these six days was 2,865.62 grains. During these six days Weston gained two pounds and two ounces in weight,† or 14,875 grains, which I assume to be muscular tissue, containing 446.25 grains of nitrogen. This nitrogen, which for sake of argument I assume went to accumulation of body-weight, is to be deducted from the nitrogen of food, the remainder being nitrogen assumed to have been expended in the force required for "nervous action, assimilative, secretory, or nutritive action, heat, etc." Making this deduction, there remain 2,419.37 grains of nitrogen of food not expended in muscular work (for there was no muscular work) and not going to increase the body-weight. The force-value of this nitrogen, according to Dr. Pavy's formula, equals 5,892.37 foot-tons. Assuming that this nitrogen represents the force required for "the internal operations going on in the system," it may be deducted

* Payen, "Précis théorique et pratique des substances alimentaires," Paris, 1865, p. 488.

† "The Lancet," London, March 11, 1876, pp. 392, 394.

from the force-value of the nitrogen of food and of the nitrogen of muscular tissue disintegrated during the six days' walk. Making this deduction, the estimated force-value of the nitrogenous food in excess of that assumed to be used in the "internal operations," with the muscular tissue consumed and not repaired, as estimated by loss of weight, is equal to 6,225.07 foot-tons. The actual work performed, reduced to foot-tons, was 7,026.06. The difference of 800.99 foot-tons, which can not be accounted for by the nitrogenous food and muscle consumed, must be attributed to errors in the formulas by which the calculations are made.

To render my argument complete so far as can be done with the data at my command, I shall now apply the same methods of calculation to my own observations on Weston in 1870.

For five days before the walk, the nitrogen of food was 1,697.30 grains, the force-value of which is equal to 4,133.77 foot-tons. I add 1.3 pound of weight lost, which is represented by 273 grains of nitrogen, the force-value of which is equal to 664.89 foot-tons, making a total force-value of nitrogen of food and nitrogen of muscle consumed of 4,798.66 foot-tons. From this I deduct forty-one miles walked as equal to 578.72 foot-tons of work. This leaves 4,219.94 foot-tons of work used in the "internal operations." In the calculations made from Dr. Pavy's observations on Weston for six days of rest before the walk, I found that the force used in the "internal operations" was equal to 5,892.37 foot-tons, or nearly forty per cent. more than in my observations.

I assume that the force used in these "internal operations" was nearer the normal standard during the five days before the walk than for the five days after the walk, when the system was recuperating after such unusual muscular exertion.

During the five days of the walk of three hundred and seventeen and one-half miles, the nitrogen of food was 1,173.82 grains, the force-value of which is 2,858.79 foot-tons. The loss of weight was 3.45 pounds, representing 724.5 grains of nitrogen, having a force-value of 1,764.52 foot-tons. This, added to the force-value of the nitrogenous food, gives a total force-value of nitrogenous food

and muscle consumed of 4,623.31 foot-tons. If I now deduct the force used in the "internal operations," as calculated for the five days before the walk, I have 403.37 foot-tons of force with which to accomplish a walk of three hundred and seventeen and a half miles. The actual work performed in walking three hundred and seventeen and a half miles, using Dr. Pavy's method of calculation, is equal to 4,321.33 foot-tons,* as is seen by the following table:

MILES WALKED IN FIVE DAYS REDUCED TO FOOT-TONS

	Weight.	Miles walked.	Foot-Tons.
First day	116.50 lbs.	80	1,098.43
Second day	116.25 " (Estimated.)	48	657.64
Third day	115.00 lbs.	92	1,246.97
Fourth day	114.00 "	57	765.80
Fifth day	115.75 "	40½	552.49
Totals	....	317½	4,321.33

This calculation shows that the actual work performed is more than ten times the estimated force-value of the nitrogenous food and muscle consumed, deducting that used in the "internal operations"; and estimating for the weight of clothing carried, it is even more than the total force-value of food and muscle consumed, taking no account of the force used in circulation, respiration, etc. There must be some serious error in the basis of calculations the results of which appear to be so far removed from the actual facts.

Again, looking at the probable force employed in the "internal operations" for the five days after the walk, I find that the nitrogen of food was 2,204.65 grains. I deduct from this the five pounds gain in weight, which represent 1,050 grains of nitrogen. This leaves 1,154.65 grains of nitrogen, the force-value of which is 2,812.15 foot-tons.

* In estimating the work I have calculated the weight of the body without clothing. The actual work performed, according to the formula of Haughton, would be more than that which I have given; but I thought it better to calculate from my actual figures than to add an indefinite quantity of probable weight of clothing. Estimating the clothing at ten pounds, the additional work for the five days would amount to 375.09 foot-tons, making the total work equal to 4,696.42 foot-tons, 73.11 foot-tons more than the total estimated force-value of food and muscle consumed.

If I deduct from this the force represented by walking eleven miles, which is equal to 156.21 foot-tons, I have remaining, for the force used in the "internal operations," 2,655.94 foot-tons. This is rather more than one-half and a little less than two-thirds of the force estimated as used in the "internal operations" for the five days before the walk.

The calculations made by Dr. Pavy are entirely different in principle from those which I have just detailed. He estimates the force-value of nitrogenous matter consumed as represented, not by the nitrogen of food and muscle used, but by the nitrogen excreted. This does not appear to me to be so rational and philosophical a method as the one employed by me, for the following reasons:

I. While, in normal nutrition, there would be an exact balance between the ingress and egress of nitrogen, provided the weight of the body is uniform, in Dr. Pavy's observations for the six days of rest, 22.35 to 50.98 per cent. of the nitrogen of food is lost and can not be accounted for by the nitrogen excreted. It can not be assumed, upon the principles laid down by Dr. Pavy, that the nitrogen which has thus escaped observation is actually lost or that nitrogenous matter is consumed without the evolution of force. It can only be said that its changes have escaped observation. In all experiments in regard to the ingress and egress of nitrogen with which I am acquainted, a certain proportion of nitrogen appears to be lost, or at least it is not represented in the excretions. This is probably due to imperfections in methods of investigation.

II. The data from which my calculations were made had their starting-point in positive information in regard to the quantity of nitrogen taken in the food. This being ascertained, it seems to me much more rational to calculate the power from the nitrogen consumed than from the nitrogen of the excretions. If it is assumed that at the beginning of the walk Weston was in what athletes would call "good condition," the system being free from fat so far as fat can be eliminated by training, it is rational to assume that the muscular tissue consumed, as measured by loss of weight during exercise, was used in the production of force, and the force-value of this muscular tissue consumed should be added to the force-value of the food.

Adopting the method of calculation employed by Dr. Pavy, the impossibility of accounting for the work actually performed under his observation, by calculating the force-value of matter represented by the nitrogen excreted, is more striking than is shown by the results of my method of calculating the force-value of the nitrogenous food taken. Dr. Pavy, taking all of his observations on Perkins and Weston, estimates the actual work accomplished for each day in foot-tons. He then calculates the "force-value in foot-tons of nitrogenous matter equivalent to the total urinary nitrogen eliminated." He then calculates the "force-value in foot-tons of nitrogenous matter equivalent to the nitrogen eliminated in excess of the average during rest." His remarks on these figures are the following:

	Weight of Pedestrian in lbs.	Distance walked in Miles.	Work performed, represented in Foot-Tons.	Force-Value in Foot-Tons of Nitrogenous Matter, equivalent to the Total Urinary Nitrogen eliminated.	Force-Value in Foot-Tons of Nitrogenous Matter, equivalent to the Nitrogen eliminated in Excess of the Average during Rest.
Perkins' 24 hours' walk...	137	65½	1057.59	1462.83	718.98
First 24 hours of Weston's 48 hours' walk........	137¾	100	1623.48	1341.83	597.98
Second 24 hours of Weston's 48 hours' walk....	133	80½	1261.83	1124.15	380.30
First 24 hours of Weston's 75 hours' walk........	137	104	1679.23	1208.52	464.67
Second 24 hours of Weston's 75 hours' walk ...	135	76	1209.21	1373.13	629.28
Third 24 hours of Weston's 75 hours' walk ...	134	83	1310.80	1298.39	554.53
First 24 hours of Weston's 6 days' walk..........	134 13/16	96	1525.30	1277.63	533.78
Second 24 hours of Weston's 6 days' walk	132 13/16	77	1205.27	1418.48	674.63
Third 24 hours of Weston's 6 days' walk	132 1/16	70½	1097.29	1462.00	718.15
Fourth 24 hours of Weston's 6 days' walk	132 9/16	76½	1105.19	1225.56	481.71
Fifth 24 hours of Weston's 6 days' walk..........	131⅛	67	1035.44	1096.12	352.27
Sixth 24 hours of Weston's 6 days' walk..........	130 5/16	63	967.57	1141.51	397.66

"In one column is the weight of the pedestrian; in the next the distance walked; and then follow the measure of work to which these two factors correspond, the work-value of the nitrogenous matter equivalent to the total urinary nitrogen eliminated; and, lastly, the work-value of the nitrogenous matter equivalent to the

urinary nitrogen excreted in excess of the average for the total days of rest. I consider that this is the column which ought to be followed, for it is clearly this which represents the disintegrated nitrogenous matter arising from the walk performed. For instance, during the days of rest there was a certain amount of disintegration of nitrogenous matter occurring as a result of the internal operations going on in the system. The disintegrated nitrogenous matter thus resulting, taking the average of all the days (fifteen) of rest, corresponded with 305.42 grains of eliminated nitrogen. It may be fairly assumed that the same, or about the same, disintegration would ensue during the days of the walk, and independently of the effects of the walk. To represent, therefore, the disintegration occurring as a result of the walk, we ought strictly to deduct that which the data show would have occurred without it.

"The above figures speak for themselves. A glance at them is sufficient to show that the force obtainable from the nitrogenous matter disintegrated is totally inadequate to supply the power for the work performed. In every case the force-value of the nitrogenous matter standing in excess of that disintegrated according to the average for the days of rest, and representing, it may be considered, the effect of the exercise, falls very far short of the power expended in walking. Upon only four occasions does it amount to more than half, and upon two it is less than a third. Even in five out of the twelve days the force-value of the total nitrogenous matter disintegrated is below the force employed." *

I have gone thus fully into a discussion of the application of what is known concerning the force-value of nitrogenous food, as calculated from the heat-units, to muscular power, for the reason that the application of the known laws of dynamics to physiological processes has lately become an important element in the study of physiology. It is to be feared, however, that physiologists are often reasoning in advance of experimental development of facts, and theorizing upon the basis of formulas so inaccurate, that when they come to the consideration of millions of foot-pounds, the variations between the facts and their calculations become enormous. If such a method of study is accurate, the advantages of its application to physiology are almost incalculable. If it is shown to be grossly erroneous, it should be abandoned until data are more complete and definite. I can not see how one can avoid banishing, for the present at least, these uncertain and erroneous processes from physiological research as applied to the theories of muscular action and the source of muscular

* "The Lancet," London, December 16, 1876, pp. 849, 850.

power; and I may sum up my reasons for this view in the following statements:

I. The only definite fact available in such calculations as are made by Haughton, Dr. Pavy and others, is "that the force derived from chemical action which will raise the temperature of a pound of water 1° Fahr. will, under another mode of manifestation, lift 772 pounds one foot high."

II. According to this proposition, if food is burned in oxygen, it will develop a definite quantity of heat, which is calculated to be equivalent to a certain number of foot-pounds of force.

III. In applying this method of reasoning to the development of force produced by the metamorphosis which nitrogenous food undergoes in the animal organism, a calculation is made of the exact force-value of food; but the processes going on within the animal organism are so complex and so imperfectly understood, that it is necessary to establish a certain relation between the calculated force-value of the food and the actual force exerted under certain conditions. Experimental attempts to establish such a relation have signally failed.

IV. It can not be estimated with any approach to scientific accuracy how much force is exerted by the heart. One observer makes this force nearly double that estimated by another.* Dr. Haughton bases his estimate upon the proposition that the left ventricle discharges three ounces of blood at each contraction. There is good physiological authority for the opinion that the quantity discharged at each pulsation is five to six ounces. An error in this estimate, when it is remembered that this error must be multiplied by more than 100,000 beats of the heart in twenty-four hours, it is evident, would be fatal to the accuracy of any calculations.

V. It is impossible to arrive at any reasonably accurate estimate of the force exerted in the movements of respiration.

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* I may illustrate the differences in the estimates of different observers by stating that Haughton estimates the "total daily work of both ventricles" as equal to 124.208 foot-tons, or 621.04 foot-tons for five days. Letheby calculates the daily work of the heart (seventy-five beats in a minute) as equal to 223.23 foot-tons, or 1,116.15 foot-tons for five days.—(Haughton, "Principles of Animal Mechanics," London, 1873, p. 145; and Letheby, "On Food," New York, 1872, p. 96.)

VI. There can be no experimental estimate, unless it is based on calculations derived from the heat-units of food, of the quantity of heat generated within the body under such conditions as those presented in the observations now in question. It has been possible to estimate approximately the actual production of heat by the body in a state of rest, but during violent exercise in the air, it seems impossible to calculate the radiation of heat from the surface with any degree of accuracy, and the production of heat under such conditions must remain, for the present at least, an unknown quantity.

VII. It is necessary to have an accurate estimate of the force used in circulation, respiration and in the production of animal heat, so that this force may be deducted from the force-value of food, in estimating the force used in ordinary muscular work.

VIII. If the calculations of the actual force used in muscular work are made from persons walking, there must be some accurate method of reducing this force, for purposes of comparison, to foot-pounds or foot-tons. I can not accept the proposition that the work accomplished in walking on a level is equal to raising one-twentieth of the weight of the body the distance walked, as is done by Dr. Pavy in his calculations. This is taken from Haughton's calculations, in which the velocity was three miles per hour,* while the actual velocity in Dr. Pavy's observations must have been between four and one-half and five miles per hour.† It would seem sufficiently evident, from the propositions which I have just stated, that Dr. Pavy's estimates must be wanting in accuracy, as nearly all of the elements entering into his calculations are necessarily indefinite. In calculating from his observations upon Weston, the facts of which I assume to be nearly accurate, more than eleven per cent. of the work actually accomplished can not be accounted for either by the force-value of nitrogenous food or by the force-value of muscular substance consumed and not repaired. I assume, also, that the facts obtained in my observations are nearly accurate. In these,

* Haughton, "Principles of Animal Mechanics," London, 1873, p. 57.

† In the observations which I made upon Weston in 1870, the rate of walking for the five days averaged between four and one-half and five miles per hour.

the actual work accomplished in a walk of three hundred and seventeen and one-half miles in five days was more than ten times the estimated force-value of nitrogenous food and muscle consumed, deducting the force used in circulation, respiration, etc.

Assuming that force is evolved only as a consequence of the metamorphosis of matter, and that it is only food and muscle—and perhaps fat—that can undergo changes producing force in muscular work, when calculations show a large excess of force actually produced over the estimated force-value of nitrogenous food and of muscle consumed, it is evident that there must be a serious error, either in the measurement of the force produced or in the calculations of the force-value of matters consumed or in both. There is probably an error in both. The reduction of level miles walked to foot-tons is inaccurate; an accurate estimation of the force used in circulation, respiration, etc., seems at present impossible; and the assumption that the force-value of nitrogenous food, calculated by reducing heat-units developed by burning the food in oxygen to foot-tons, can be applied absolutely to the changes which food undergoes in the human body has no argument in its favor drawn from experimental facts. Still, no one can say that matter can be actually destroyed, that matter can undergo certain chemical changes without the development of force or of heat which represents force, or that force can be developed in the body without some change in matter. My only argument is that purely physical laws can not as yet be applied absolutely to operations in the living organism.

Putting aside for the present theoretical considerations, I propose to discuss what can be learned from the facts developed by the observations made by Dr. Pavy on Perkins and Weston in 1876, and by myself upon Weston in 1870.

Dr. Pavy's first observation is upon Perkins, who walked sixty-five and one-half miles in twenty-four hours. During this time he took 315.50 grains of nitrogen in food and excreted 600.63 grains of nitrogen in urea and uric acid. For every 100 parts of nitrogen of food he excreted 190.37 parts of nitrogen in the urine. A number of days after, Dr. Pavy noted the nitrogen consumed and

excreted by Perkins for a day of rest. He took in 357.68 grains with the food and discharged 273.90 grains in the urine, or 76.57 parts for every 100 parts of nitrogen of food. So far as this observation goes, it shows that the work of walking sixty-five and one-half miles in a day increased the proportional elimination of nitrogen in the urine nearly two hundred and fifty per cent. No account is given of the variations in weight produced by the walk. The greatest proportional increase in the excretion of nitrogen which I observed for any one day in Weston was 224.32 per cent.

Dr. Pavy's observations on Weston during a walk of forty-eight hours showed the following: During the first twenty-four hours, walking one hundred miles, Weston took 65.68 grains of nitrogen in his food (an exceptionally small quantity), and excreted 550.95 grains in the urine. For every 100 parts of nitrogen of food he excreted 838.84 parts of nitrogen by the urine. During the second twenty-four hours the quantity of nitrogen of food was still quite small (161.72 grains), and the nitrogen of the urine was 461.57 grains, or 285.41 parts for every 100 parts of nitrogen of food. Comparing this with the average proportion of nitrogen excreted for eight days of rest (Weston), which is 60.90 parts excreted by the urine for every 100 parts in the food, the figures show a very large proportional increase of excreted nitrogen, which can be attributed only to the excessive muscular work. The unusually small quantity of nitrogen taken in the food evidently could not supply the waste of tissue, which amounted to a loss of body-weight of four and three-fourths pounds; but it must be evident to any one that the excessive proportional excretion of nitrogen was produced, in this instance at least, by the muscular work, and that it bears a certain relation to the muscular tissue consumed. This observation is instructive as showing the effects of excessive muscular work with a great deficiency in the supply of reparative matter. I shall discuss this point more fully in connection with my own observations, in which, as I knew, Weston was in what would be called "good condition." In Dr. Pavy's observations, I do not know the fat that may have been lost during the walk.

The next observations by Dr. Pavy were on Weston in a walk of seventy-five hours. For twenty-four hours of rest preceding this walk, with 523.11 grains of nitrogen of food—a little above the usual quantity at rest—he excreted a percentage of 57.96 of nitrogen in the urine. On the first day of the walk, with 522.42 grains of nitrogen of food, he excreted 94.98 per cent. in the urine. On the second day, with 871.92 grains of nitrogen of food—the largest quantity noted for any one day—he excreted 64.66 per cent. in the urine. On the third day, with 713.96 grains of nitrogen of food, he excreted 74.67 per cent. in the urine. On a day of rest immediately following this walk, when he was recuperating from the effects of the exertion, with 645.11 grains of nitrogen of food, he excreted only 36.41 per cent. of nitrogen in the urine, the lowest proportional excretion observed for any one day. These figures show a very large proportional increase in the excretion of nitrogen during the walk, which must be attributed to the muscular work; but the proportional increase is not so great as in the forty-eight hours' walk, for the reason that the supply of nitrogen in the food appeared to be sufficient to repair the waste of tissue—if it is assumed that the work produced waste of tissue, as it must have done in the walk of forty-eight hours. The loss of weight was three pounds, but it is impossible to say how much of this loss was fat or water.

Dr. Pavy's next observations were on Weston's six days' walk. During six days of rest just before the walk, the average nitrogen of food daily was 477.60 grains, the average nitrogen excreted in the urine daily was 319.91, or 66.98 parts for every 100 parts of nitrogen of food.

During the six days of the walk, the total distance walked being four hundred and fifty miles, the average nitrogen of food daily was 671.72 grains. This is a very large quantity, nearly three times the average obtained by me for a five days' walk. The average daily excretion of nitrogen in the urine was 521.54 grains. This is also a very large quantity, fifty-four per cent. more than I obtained for a five days' walk. For every 100 parts of nitrogen of food during this six days' walk, Weston excreted 77.64 parts in the urine, against 66.98 parts during six days of rest.

No calculations can be made for the six days of rest immediately after the walk, as the nitrogen of food was not estimated. It is stated that the diet "comprised a generous daily mixed allowance of animal and vegetable food." The average nitrogen excreted daily in the urine for the six days of rest after the walk was 308.30 grains, a little less than the average quantity for the six days of rest before the walk. It is probable that while recuperating for six days after the walk the quantity of food was greater than for the six days before the walk.

During the six days' walk there was nothing notable except a large proportional excretion of nitrogen on the first day (106.67 per cent.), when he walked ninety-six miles, the longest distance walked in any one day.

Another important criticism which I have to make in regard to the observations of Dr. Pavy is that he took no account of the nitrogen discharged in the feces, which certainly should have been estimated as nitrogen discharged from the body and should have been deducted from the nitrogen assumed to have been consumed.

As regards the observations on Weston during the six days' walk, the same remarks apply as those made for the seventy-five hours' walk. The figures show a large proportional increase in the excretion of nitrogen during the walk over the excretion during the six days of rest immediately preceding. This, as Dr. Pavy admits, is to be attributed only to the influence of the muscular work. It is a noticeable fact, however, that the quantity of nitrogen taken in the food during the walk was very large; and the food undoubtedly supplied the excessive waste of tissue produced by the extraordinary exertion to a much greater extent than during the five days' walk observed by me in 1870. It probably prevented a complete breaking down, such as occurred on the fourth day of my observations. On this day the nitrogen of food was only 144.70 grains; the excretion by the urine was 324.59 grains, or 224.32 parts for every 100 parts of nitrogen of food; the proportional excretion for the three days before had amounted to a daily average of 163.86 per cent.; and the loss of weight for the four days had been 5.2 pounds. The muscular system then seemed to be incapable of further work. Weston became almost blind, and he was taken

from the track and supported to his room. If Weston had been able to supply his waste of tissue by food, this collapse of muscular power might not have occurred.

It is evident that in Dr. Pavy's observations the proportional discharge of nitrogen during the six days' walk was less than in mine, for the reason that the nitrogen of food was very much greater, being more than double the quantity that I obtained; but it is evident, also, that in my experiments Weston suffered from want of food, and the increased quantity of food under Dr. Pavy's observation was useful in repairing the muscular tissue.

I have separated the different series of observations made by Dr. Pavy, for the reason that one series was made on Perkins and the others on Weston; and also because the conditions of alimentation in the different series of observations upon Weston presented great variations, which were particularly noticeable in the forty-eight hours' walk.

Important changes occurred in the quantities of inorganic matters in the urine during the extraordinary exertions made under Dr. Pavy's observation. Dr. Pavy's results in this regard were nearly the same as mine. The physiological significance of these changes is not very clear, and I refrain from discussing them for the reason that they seem to have no direct relations to the source of muscular power.

MY OWN EXPERIMENTS, MADE IN 1870 AND PUBLISHED IN 1871

In discussing my own experiments, which I can now do more satisfactorily than before by reason of the confirmatory results obtained by Dr. Pavy, I feel that I am justified in claiming priority in the method of investigating the influence of exercise upon the excretion of nitrogen by comparing the nitrogen eliminated with the nitrogen of food.

I endeavored to make my experimental data complete and accurate, and to gather and group my facts with entire freedom from theoretical bias. I was with Weston for the entire fifteen days, and had an assistant who never left him for an instant and even slept with him at night. Every article of food and drink was weighed or measured and the

proportion of nitrogen estimated. No part of the urine or feces was lost. No accident happened, the weights were all taken naked and the subject of the experiments was under observation every instant. The chemical analyses were all made by a chemist who had no idea of the ultimate bearing of the results which he was to present to me for tabulation. Probably the only error in these analyses was in the estimation of the uric acid. This was not so considerable as to affect the conditions in any way, and the same error extended through all the examinations, so that it could not modify the comparative results. In my calculations of average percentages I made the error of taking the average of the percentages instead of the percentage of the averages. This I corrected in "The Journal of Anatomy and Physiology," Cambridge and London, October, 1876. Dr. Pavy takes me to task for this error in "The Lancet," London, December 23, 1876, some time after it had been corrected; but my correction of the figures shows that the error in no way affected my general conclusions.*

In the table on page 45, which gives the most important results of my experiments, the error alluded to above has been corrected. I have also left out the estimates of the nitrogen of the feces and added the nitrogen of the uric acid, so as to be able to make a more accurate comparison of my results with those obtained in England.

After the full discussion that I have given of Dr. Pavy's results, in which I have referred more or less fully to my own observations, a very brief general statement of the main facts embodied in the table will suffice.

My observations were made for three periods of five days each, before, during and after the walk of three hundred and seventeen and a half miles in five consecutive days.

For the five days immediately preceding the walk the average daily quantity of nitrogen ingested was 339.46 grains. The average daily quantity of nitrogen excreted in the urine was 293.93 grains. The proportional excretion of nitrogen was 86.58 parts for every 100 parts of nitrogen of food.

* In Article XIX. the errors referred to above have been corrected.

Table of Results obtained for Days of Walking and for Days of Rest

Flint, "Physiological Effects of Severe and Prolonged Muscular Exercise."—"New York Medical Journal," June, 1871.

	First 24 Hours of 5 Day Period prior to Weston's 5 Days' Walk.	Second 24 Hours of 5 Day Period prior to Weston's 5 Days' Walk.	Third 24 Hours of 5 Day Period prior to Weston's 5 Days' Walk.	Fourth 24 Hours of 5 Day Period prior to Weston's 5 Days' Walk.	Fifth 24 Hours of 5 Day Period prior to Weston's 5 Days' Walk.	First 24 Hours of Weston's 5 Days' Walk.	Second 24 Hours of Weston's 5 Days' Walk.	Third 24 Hours of Weston's 5 Days' Walk.	Fourth 24 Hours of Weston's 5 Days' Walk.
Body - Weight (without Clothing)	120.5 lbs.	121.25 lbs.	120 lbs.	118.5 lbs.	119.2 lbs.	116.5 lbs.	116.25 lbs.	(Estimate) 115 lbs.	114 lbs.
Miles walked	15	5	5	15	1	80	48	92	57
Nitrogen of Food	361.22 grs.	288.35 grs.	272.27 grs.	335.01 grs.	440.43 grs.	151.55 grs.	265.92 grs.	228.61 grs.	144.70 grs.
Nitrogen of Urea and Uric Acid	304.55 "	276.84 "	305.08 "	283.87 "	299.31 "	331.44 "	328.05 "	399.16 "	324.59 "
Per cent. of Nitrogen excreted in Urea and Uric Acid	84.31	96.01	112.05	84.73	67.96	218.70	123.36	174.60	224.32

Table of Results obtained for Days of Walking and for Days of Rest (Continued)

	Fifth 24 Hours of Weston's 5 Days' Walk.	First 24 Hours after Weston's 5 Days' Walk.	Second 24 Hours after Weston's 5 Days' Walk.	Third 24 Hours after Weston's 5 Days' Walk.	Fourth 24 Hours after Weston's 5 Days' Walk.	Fifth 24 Hours after Weston's 5 Days' Walk.	Daily Averages for the 5 Days of Rest prior to Weston's 5 Days' Walk.	Daily Averages for the 5 Days of Rest after Weston's 5 Days' Walk.	Daily Averages for the 10 Days of Rest.	Daily Averages for the 5 Days of Walking.
Body - Weight (without Clothing)	115.75 lbs.	118 lbs.	120.25 lbs.	120.25 lbs.	123.5 lbs.	120.75 lbs.	119.89 lbs.	120.55 lbs.	120.22 lbs.	115.5 lbs.
Miles walked	40.5	2	2	2	2	3	8.2	2.2	5.2	63.5
Nitrogen of Food	383.04 grs.	385.65 grs.	499.10 grs.	394.83 grs.	641.71 grs.	283.35 grs.	339.46 grs.	440.93 grs.	390.19 grs.	234.76 grs.
Nitrogen of Urea and Uric Acid	306.80 "	277.00 "	334.44 "	358.78 "	348.19 "	379.79 "	293.93 "	339.64 "	316.78 "	338.01 "
Per cent. of Nitrogen excreted in Urea and Uric Acid	80.09	71.82	67.01	90.87	54.26	134.03	86.58	77.03	81.18	143.98

At the beginning of the walk Weston appeared to be in good condition, with no superfluous fat, and his weight without clothing was 119.2 lbs. During the five days he walked three hundred and seventeen and a half miles. His daily average of nitrogen of food was 234.76 grains. His daily average excretion of nitrogen in the urine was 338.01 grains. The proportional excretion of nitrogen was 143.98 parts for every 100 parts of nitrogen of food. It is evident, therefore, that the nitrogen of food did not supply the waste of the nitrogenous constituents of the body, as it may be supposed to have done in Dr. Pavy's observations.

The most notable event in the course of the five days' walk was what appeared to be a total collapse of muscular and nervous power, to which I have already referred, occurring on the fourth day. I quote the following account of this from my original article, in which I calculated the nitrogen of the urea and the feces * and took no account of the uric acid:

"On the third day Weston walked ninety-two miles, with thirty minutes of sleep. The entire quantity of nitrogen of the urea (no feces were passed) was very large, amounting to 397.58 grains, representing 851.95 grains of urea, by far the largest quantity discharged in any one of the five days. This corresponded to the greatest amount of muscular exertion, a fact which is very significant. The nitrogen of the food was slightly diminished, amounting to 228.61 grains. For every 100 parts of nitrogen introduced, there were discharged, 173.91 parts. This excessive discharge of nitrogen can be attributed only to the muscular exertion. On that day Weston took six pints of strong coffee, which, if it had any effect, would have diminished the elimination of urea.

"On the fourth day Weston walked fifty-seven miles, with one hour of sleep. The nitrogen of the urea and feces was 348.53 grains. The nitrogen of the food was on this day diminished to the minimum, being only 144.70 grains. For every 100 parts of nitrogen introduced, there were discharged, 240.86 parts, the largest excess observed during the five days.

"At 10.30 P. M., on this day, Weston broke down completely. He could not see the track and was taken staggering to his room, having reached apparently the limit of his endurance. His condition at that time, as shown by the records, was as follows: He had lost in weight 83.2 oz., being reduced from 119.2 lbs. to 114 lbs. He had taken a daily average of 197.70 grains of nitrogen

* The nitrogen of the feces for the first four days of the walk was 95.42 grains.

in his food, while walking an average of sixty-nine and a quarter miles per day, with an average of sleep in each twenty-four hours of 1 hour and 44 minutes for four days. His daily average of nitrogen should have been 310 grains, not allowing for an increased quantity demanded to supply the waste engendered by his excessive muscular exertion. He had discharged for every 100 parts of nitrogen introduced, a daily average of 186.37 parts for four days. The calculations, as well as the general condition of the system, show that the period had probably arrived when repair of the muscular tissue had become absolutely necessary.

. . . .

"On the fifth day, after 9 hours and 26 minutes of sleep, the system reacted completely, and Weston walked forty and a half miles. The nitrogen of the urea and feces was 332.77 grains. The nitrogen of the food was increased one hundred and sixty-five per cent., being 383.04 grains. For every 100 parts of nitrogen of food there were discharged, 84.27 parts. The absolute quantity of nitrogen discharged was still very great; but its proportion to the nitrogen taken in was reduced by the large quantity in the food.

"On this day, when there was an apparent reaction after the complete prostration of the fourth day, the system seemed to appropriate nitrogen with avidity, to repair the impoverished muscular tissue. The weight was increased on this day by 28 oz."

There is one important series of calculations made by me for the five days of the walk in 1870, which I can not make from Dr. Pavy's experiments, for the reason that I do not know the physical "condition" of Weston when the observations were made.* At the beginning of the walk made in 1870, thirty minutes before starting he weighed 119.2 lbs. without clothing. There was no superfluous fat, and he started apparently with his system in such a condition that nearly all the variations in weight

* One hour and a half before Weston began his six days' walk, he weighed 123.75 lbs., without clothing ("The Lancet," March 18, 1876, p. 430), which was 4.55 lbs. more than he weighed in 1870, at the beginning of his five days' walk. I am unable to determine what part, if any, of this excess of weight was fat. During the six days' walk he excreted 3,129.27 grains of nitrogen in the urine, which was 1,101.21 grains more than the daily average for the five days' walk multiplied by six. During the same time he took 4,030.34 grains of nitrogen in the food, which was nearly three times the average for the five days' walk multiplied by six. At the end of the six days' walk he had lost 5 lbs. 5 oz., having been reduced in weight to 118 lbs. 7 oz. ("The Lancet," March 18, 1876, p. 431), or only about 12 oz. less than he weighed in 1870, when he began his five days' walk. This loss in weight occurred in the six days' walk, when he had been taking in much more nitrogen than he excreted. The uncertainty in regard to the fat which he may have lost, the large quantity of food taken, and the fact that while losing largely in weight he actually took in more nitrogen than he excreted, render it impossible for me to make any calculations in regard to the relations between the excretion of nitrogen and the loss of body-weight for the six days' walk.

could be attributed to a loss of muscular substance not repaired by food. This is an important consideration, for loss of fat could not be calculated from any data furnished by an analysis of the food and excretions for nitrogen. The loss of water might become a slightly disturbing element, for it is well known that three or four pounds may be lost in a Turkish bath, without any muscular exertion; but I assume that this element of error can not have been very considerable, as Weston took all the liquids he desired during the five days, and it is probable that he promptly supplied in this way the water lost by cutaneous transpiration. When a person loses two or three pounds in a Turkish bath, the water usually is restored by drink in the course of a few hours.

At the end of the five days' walk the weight had been reduced from 119.20 to 115.75 lbs., showing a loss of 3.45 lbs. According to Payen, three parts of nitrogen represent one hundred parts of fresh muscular tissue.* The total quantity of nitrogen contained in the urea, uric acid and feces † discharged during these five days was 1,811.62 grains. The total nitrogen of food during the same period was 1,173.82 grains, giving an excess of 637.80 grains of nitrogen discharged over the nitrogen of food. The 637.80 grains of nitrogen, according to Payen's formula, would represent 21,260.00 grains, or 3.037 lbs. of muscular tissue. The actual loss of muscular tissue was 3.45 lbs., and the loss unaccounted for, which was 0.413 lb., is very small. It might be fat or water or the difference might be due to inaccuracies in the estimates of the nitrogen of food, which of necessity were approximative.

It is thus seen that my observations on Weston's walk of three hundred and seventeen and a half miles in five days show, not only that the excessive exercise increased the amount of nitrogen discharged over the nitrogen taken in with the food, but that the excess of the nitrogen discharged over the nitrogen of the food, calculated as representing muscular tissue destroyed, was nearly equal to the actual loss of weight during the walk. This calculation is made on the assumption that when Weston began his

* Payen, *op. cit.*, p. 488.
† The nitrogen of the feces for the five days was 121.58 grains.

walk nearly all the fat had been eliminated from the body and that the loss of weight involved the muscular system almost exclusively.

The observations during the five days after the walk, with very little exercise, show that the gain in weight was five pounds, and that the nitrogen of food was 2,204.64 grains, while the nitrogen of the urea, uric acid and feces was 1,868.13 grains, giving an excess of nitrogen of food of 336.51 grains. This excess of nitrogen would build up 1.602 of a pound of muscular tissue. It is fair to suppose that under a liberal diet after such severe exertion, and without exercise for five days, the remaining 3.398 lbs. of gain in weight probably was fat and not muscle.

CONCLUSIONS

I. While nitrogenous food burned in oxygen out of the body will produce a definite amount of heat which may be calculated as equivalent to a definite number of food-pounds of force, the application of this law to the changes which food or certain of the constituents of the body undergo in the living organism is difficult and unsatisfactory, for the following reasons:

(a) It has not yet been shown that nitrogenous food undergoes the same changes in the living body as when burned in oxygen or that the heat and force incident to their metamorphoses can be accurately measured.

(b) Assuming that food contains a definite quantity of locked-up force, to measure the part of this force which is expended in general muscular work, it is indispensable to be able to estimate accurately the force used in circulation, respiration and the various nutritive processes and to measure the heat evolved which maintains the standard animal temperature and which compensates the heat lost by evaporation from the general surface. It does not seem that any accurate idea can be formed of the force used in circulation and respiration; and the estimates made by different observers of authority present variations sometimes of more than one hundred per cent. Such estimates are usually made in view of some dynamic theory, and they are based on physiological data which are necessarily uncertain and subject to wide and frequent variations. No ap-

proximate estimate, even, can be made of the total heat produced within the living organism, except, perhaps, during a condition of nearly absolute muscular rest. The only way in which this could be done would be to deduct the force used in muscular work, circulation, respiration and the nutritive processes from the heat or force-value of the food. These elements of the question being uncertain, an accurate estimate of the heat produced becomes impossible, as at the best the only definite quantity in the problem is the total heat or force-value of food.

(c) To compare the muscular work actually done with the estimated force-value of food, apart from the impossibility of arriving at an accurate estimate of what is consumed in circulation, respiration, the nutritive processes and the production of heat, which is a necessary element in the problem, the work actually done in walking a certain distance must be reduced to foot-pounds or foot-tons. The formula for this is so uncertain that no such reduction can be made that can be assumed to be even approximately correct.

II. The method of calculating the possible force of which the body is capable, by using as the sole basis for this calculation the force-value of food, must be abandoned until the various necessary elements of the problem can be made sufficiently accurate to accord with the results of experiments upon the living body. Until that time physiologists should rely on positive results obtained by experiments rather than on calculations made from uncertain data. In case of fatal disagreement between any theory and definite experimental facts, the theory should be abandoned, provided the facts are incontestable.

III. Experiments show that the estimated force-value of food, after deducting the estimated force used in circulation, respiration, the nutritive processes, and the production of heat, will sometimes account for a small fraction only of muscular work actually done, this work being reduced to foot-tons by the uncertain process to which I have already alluded. The errors in these calculations are manifestly so considerable that the results seem to be of little value, while the experimental fact that a certain amount of work has been accomplished must remain.

IV. It must be admitted that under ordinary and

normal conditions of diet and muscular exercise, the weight of the body being uniform, the ingress and egress of matter necessarily balance each other. If this balance is disturbed by diminishing the supply of food below the requirements of the system for its nutrition and for muscular work, the body necessarily loses weight, a certain portion of its constituent parts being consumed and not repaired. If the balance is disturbed by increasing the muscular work to the maximum of endurance and beyond the possibility of complete repair by food, the body loses weight. The probable source of muscular power may be most easily and satisfactorily studied by disturbing the balance between consumption and repair by increasing the work; and in this it is rational to assume that the processes of physiological wear of the tissues are not modified in kind, but simply in degree of activity.

V. Experiments show that excessive and prolonged muscular exercise may increase the waste or wear of certain of the constituents of the body to such an extent that it is not repaired by food. Under these conditions there is an increased discharge of nitrogen, particularly in the urine. This waste of tissue may be repaired if food can be assimilated in sufficient quantity; but in my experiments it was not repaired. The most important question to determine experimentally in this connection is in regard to the influence of excessive and prolonged muscular exercise on the excretion of nitrogen. It is shown experimentally that such exercise always increases the excretion of nitrogen to a very marked degree, under normal conditions of alimentation; but the proportional quantity to the nitrogen of food is great when the nitrogen of food remains the same as at rest, and is not so great, naturally, when the nitrogen of food is increased. In the latter case the excessive waste of the tissues is in part, or it may be wholly repaired by an increased quantity of food. Experiments on excessive exertion with a non-nitrogenous diet are made under conditions of the system that are not physiological; and the want of nitrogen in the food in such observations satisfactorily accounts for the diminished excretion of nitrogen.

VI. By systematic exercise of the general muscular system or of particular muscles, with proper intervals of

repose for repair and growth, muscles may be developed in size, hardness, power and endurance. The only reasonable theory that can be offered in explanation of this process is the following: While exercise increases the activity of disassimilation of the muscular substance, a necessary accompaniment of this is an increased activity in the circulation in the muscles, for the purpose of removing the products of their physiological wear. This increased activity of the circulation is attended with an increased activity in the nutritive processes, provided the supply of nutriment is sufficient, and provided, also, that the exercise is succeeded by proper periods of rest. It is in this way only that one can comprehend the process of development of muscles by training; the conditions in training being exercise, rest following the exercise, and appropriate alimentation, the food furnishing nitrogenous matters to supply the waste of the nitrogenous parts of the tissues. This theory involves the idea that muscular work consumes a certain part of the muscular substance, which is repaired by food. The theory that the muscles simply transform the elements of food into force directly, these elements not becoming at any time a part of the muscular substance, is not in accordance with the facts known in regard to training.

VII. All that is known in regard to the nutrition and disassimilation of muscles during ordinary or extraordinary work teaches that such work is always attended with destruction of muscular substance, which may not be completely repaired by food, according to the work performed and the quantity and kind of alimentation.

VIII. In my experiments on a man walking three hundred and seventeen and one-half miles in five consecutive days, who at the beginning of the five days had no superfluous fat, the loss of weight was actually 3.45 lbs., while the total nitrogen discharged from the body in the urine and feces in excess of the nitrogen of food taken for these five days, assuming that three parts of nitrogen represent one hundred parts of muscular substance, as has been shown by analysis to be the fact, was equivalent to 3.037 lbs. of muscular substance. This close correspondence between the actual loss of weight and the loss that should have occurred, as deduced from a calculation of

the nitrogen discharged in excess of the nitrogen of food, seems to show very clearly that during these five days of excessive muscular work, a certain quantity of muscular substance was consumed which had not been repaired, and that this loss could be calculated with reasonable accuracy from the excess of nitrogen excreted.

IX. Finally: experiments on the human subject show that the direct source of muscular power is to be looked for in the muscular system itself. The exercise of muscular power involves immediately the destruction of a certain amount of muscular substance, of which the nitrogen excreted is a measure. Indirectly, nitrogenous food is a source of power, as by its assimilation by the muscular tissue it repairs the waste and develops the capacity for work; but food is not directly converted into force in the living body nor is it a source of muscular power, except that it maintains the muscular system in a proper condition for work. In ordinary daily muscular work, which may be continued indefinitely except as it is restricted by the conditions of nutrition and the limits of age, the loss of muscular substance is balanced by the assimilation of alimentary matters. A condition of the existence of the muscular tissue, however, is that it can not be absolutely stationary, and that disassimilation must go on to a certain extent, even if no work is done. This loss must be repaired by food in order to maintain life. A similar condition of existence applies to every highly-organized part of the body and marks a broad distinction between a living organism and an artificially constructed machine, which latter can exert no motive power of itself and can develop no force that is not supplied artificially by the consumption of fuel or otherwise.

APPENDIX

In discussing the various observations that have been made on the human subject in regard to the influence of muscular exercise upon the excretion of nitrogen, I have confined myself to the question of the relations between nitrogenous food and muscular power because, in all such observations, no account has been taken of the elimination of carbonic acid.

In my experiments made in 1870 the quantities of non-

nitrogenous food were carefully noted; and it may be interesting to speculate in regard to the probable influence of such matters on the production of heat and work. I must premise, however, what I shall have to say upon this point, with the statement that I can not accept the estimates given of the force used in circulation, respiration and the production of animal heat as even approximately correct. With this reservation, I propose to discuss these estimates and see what possible relation they bear to food, including non-nitrogenous as well as nitrogenous matters.

Weston walked, under my observation, three hundred and seventeen and one-half miles in five consecutive days. Making my calculations according to the method employed by Dr. Pavy, the force-value of his nitrogenous food, during these five days, was 2,858.79 foot-tons. The force-value of his loss of weight, calculated as muscular tissue, was 1,764.52 foot-tons. During the five days he took non-nitrogenous food representing 19,521.41 heat-units, which equal 6,727.91 foot-tons of force.* All these represent the sum of the sources of power and heat with which Weston was to accomplish his walk of three hundred and seventeen and one-half miles and maintain circulation, respiration, animal temperature, etc.

The walk of three hundred and seventeen and one-half miles, according to Dr. Pavy's calculation, was equal to

* NON-NITROGENIZED FOOD TAKEN BY WESTON DURING HIS FIVE DAYS' WALK

Articles of Food.	1st Day.	2d Day.	3d Day.	4th Day.	5th Day.	Total Oz.	Total in Grains.	Heat-Units.
Milk....	5.66 oz.	5.66 oz.	6.18 oz.	8.75 oz.	9.78 oz.	36.03	15,763.125	2,585.152
Bread...	1.25 "	10.50 "	1.50 "	6.62 "	9.00 "	28.87	12,630.625	6,972.105
Oatmeal.	......	....	6.78 "	7.92 "	3.39 "	18.09	988.750	998.637
Potatoes.	......	2.00 oz.	......	......	4.00 "	6.20	2,712.500	694.400
Butter ..	2.63 oz.	0.50 "	0.50 oz.	......	1.25 "	4.88	2,135.000	3,988.180
Sugar...	1.63 "	1.75 "	2.00 "	3.62 oz.	2.37 "	11.37	4,974.375	4,282.937
Grand total of heat-units..................................								19,521.411

I have calculated the heat-units from Letheby's table ("On Food," pp. 94, 95). In the table above I have given the quantities of oatmeal-gruel taken and have estimated two ounces of oatmeal for a pint of gruel. In my calculations of the force-value of nitrogenous food I have already estimated milk, bread, oatmeal, potatoes and butter, taking the proportion of nitrogen for each of these articles. I have not included sugar before in any of my calculations.

4,321.33 foot-tons of work. According to Letheby, the force expended daily in circulation and respiration equals about 600,000 foot-pounds, or 3,000,000 foot-pounds (1,-339.29 foot-tons *) in five days. Direct observations have shown that the production of heat per pound-weight of the body per hour, in a state of rest, equals 4.158 heat-units.† This gives 98.792 heat-units per pound-weight of the body for twenty-four hours, and 11,410.476 heat-units daily for 115.5 lbs. (Weston's average weight for the five days) and 57,052.38 heat-units for five days.

Force-value of nitrogenous food............	2,858.79	foot-tons.
" " loss of weight of the body....	1,764.52	"
Total........................	4,623.31	"

These calculations show the fallacy of such estimates and the impossibility of accounting for muscular work actually performed, even when the heat-value and the force-value of non-nitrogenous food are included. The estimates of the force used in circulation and respiration and of the heat produced by the body are all calculated for a condition of rest. It is well known, however, that such unusual violent exertion as was made by Weston during his five days' walk would necessarily increase the labor of the heart and respiratory muscles and also produce a very much greater quantity of heat than during rest. This would give a much greater deficiency than is shown by the estimates I have made.‡

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* Letheby, "On Food," New York, 1872, p. 96.

† Dalton, "Human Physiology," Philadelphia, 1875, p. 302.

I calculate the heat-unit as the quantity of heat required to raise one pound of water 1° Fahr. and have reduced the calculations from kilogrammes to pounds and from centigrade to Fahrenheit degrees of the thermometer. One heat-unit, calculated as the quantity of heat required to raise one kilogramme of water 1° centigrade equals 3.96 heat-units calculated to raise one pound of water 1° Fahr.

‡ Taking the estimate of two and a half heat-units per hour per pound of body-weight (indirect method) instead of four heat-units (direct method), the deficiencies are very much reduced, being five per cent. instead of forty, not including the estimated work of the walk of 317½ miles, and thirty-seven and a half per cent. instead of fifty-five, including the estimated work of the walk. Until we shall have much more reliable estimates of the work of respiration and circulation and of other muscular work, reduced to foot-pounds, as well as the heat produced by the body, it will not be possible to account for the heat actually used in maintaining the body temperature, the heat lost by radiation and the heat used as work, without showing probable sources of heat-production largely in excess of the largest estimates of the heat actually used or dissipated. I have taken up this question in Article XXII., "Experiments and Reflections on

I have added these reflections to answer the possible objections of those who may contend that in my discussion I should have included the heat-producing and force-producing power of non-nitrogenous alimentary substances. My discussion, however, was confined mainly to the source of muscular power derived from the changes occurring in the muscular tissue, which exerts this power; these changes involving loss of muscular substance and its repair by nitrogenous food.

Animal Heat," in which I show that when muscular work is in excess of the heat represented by oxidation of non-nitrogenous and nitrogenous foods or when food is insufficient, water is produced in the body, the oxidation of hydrogen having a very high heat-value (October, 1902).

XXII

EXPERIMENTS AND REFLECTIONS ON ANIMAL HEAT

Published in the "American Journal of the Medical Sciences" for April, 1879.

Having had occasion recently to study the question of the force-value of food in connection with investigations into the source of muscular power, and the laws of conservation of force as applied to the theories of muscular action, I became much interested in the subject of animal heat. The theories of the mechanism of the production of heat by animals have lately assumed a very positive and definite form; and certain statements are now presented as facts, which appear to be entirely satisfactory to many physiologists. The questions involved are of great pathological as well as physiological importance. It is well known that the temperature of the deeper parts of the body, which are little exposed to external refrigerating influences, does not vary in health more than two or three degrees Fahr.; and that this temperature is to a great extent independent of that of the surrounding atmosphere. When from any cause, whether it is external or internal, there is a tendency to an elevation of the animal temperature, the heat is kept at the normal standard mainly by evaporation from the general surface. There is, indeed, a constant production of heat within the body, which is sufficient to maintain the animal temperature and to compensate the loss of heat from the surface. It is evident that this internal production of heat is connected with the general process of nutrition, and that it must involve changes in the form of matters within the animal organism. Carbonic acid is constantly discharged from the body, and this is one of the most important products connected with changes in matters which produce heat. The body as constantly con-

sumes oxygen, and oxidation is a process connected with most of the changes involved in calorification.

It is evident that in normal nutrition by food, the heat of the body must be maintained by changes which take place, either directly in the blood or indirectly in the tissues or in the alimentary matters, and that these changes involve oxidation to a very considerable extent. Under ordinary conditions of nutrition it is assumed that food furnishes all the material for maintaining the heat of the body and for the development of force in work such as the muscular work of respiration and circulation and general muscular effort. If no food is taken for a certain time, the heat of the body must be maintained and the work must be accomplished at the expense of the substance of the body itself; and the individual loses weight.

To furnish a positive scientific basis for the views above expressed, physiologists have burned various articles of food in oxygen and have thus calculated their heat-value. This has been expressed in what are called heat-units, the English value of a heat-unit being the heat required to raise the temperature of one pound of water one degree of the Fahrenheit scale. It is also calculated that one heat-unit converted into force will raise 772 pounds one foot high, or is equal to 772 foot-pounds. The theory of the heat-value and the force-value of food, based upon these premises, is the following:

The heat-value of food may be expressed in a definite number of heat-units. A certain proportion of these heat-units serves to maintain the standard animal temperature. A certain proportion is converted into the force used in the muscular work of respiration and circulation. A certain proportion is used in ordinary muscular work. If the supply of food is in excess of these requirements, a certain part of it is not used and the body may gain in weight. If the supply of food, however, is below the demands of the system, a part of the tissues of the body itself is consumed, and there must be a loss of weight.

There is no objection to a theory such as the one just stated on the ground of want of simplicity or comprehensiveness; but it must be admitted that many of its essential propositions are of necessity wanting in accuracy. Suppose it to be assumed as true, for sake of argument, that

one heat-unit is capable of being transformed in the body into 772 foot-pounds of force. It must be proved that a certain quantity of heat is produced by the body. A reasonably accurate estimate must be made of the force consumed in the muscular work of respiration and circulation, expressed in foot-pounds. The general muscular work of the body must also be computed in foot-pounds.

I do not propose to discuss, in this connection, the last two propositions; and I think I have shown, in another place, the considerable errors that exist in calculations by which the muscular work of the body has been reduced to foot-pounds.*

I shall discuss in this essay the estimated heat-value of certain articles of food and experiments made with reference to the heat-units actually produced by the body. I shall then give an account of observations made upon my own person, in which I endeavored to ascertain something definite in regard to the relations between the heat estimated as produced by the body, the loss of weight of the body during one day's abstinence from food and the estimated heat-value of a carefully weighed quantity of food taken during one day.

Estimated Heat-value of Certain Articles of Food.—Following the observations made by Fick and Wislicenus in 1866, by which these observers attempted to show that nearly all the force resulting from muscular action is due to the oxidation of non-nitrogenous matters, physiologists have estimated the heat-value and the force-value of different articles of food. They have reasoned that the food, by its oxidation in the body, is capable of producing a certain quantity of heat and that a part of this heat is converted into force. A method now employed to calculate the heat produced is to subtract the daily mechanical force expended from the total force-value of the food, the result giving the daily formation of heat. A recent writer estimates in this way that "between one-fifth and one-sixth of the total income is expended as muscular labor, the remaining four-fifths or five-sixths leaving the body in the form of heat." † The reduction of heat-units

* Article XXI., "Source of Muscular Power."

† Foster, "Text-book of Physiology," London, 1877, p. 323.

to units of force is made in accordance with Joule's formula, that one heat-unit is equal to 772 foot-pounds, or will raise 772 pounds one foot high.

In 1866 Frankland made a number of calculations of the heat-units and the estimated force-value of various articles of food * which are now accepted and used by most writers on subjects connected with the theories of animal heat and the source of muscular power. The experiments upon which these calculations are based were made with great care and exactness. The following quotation gives in a few words the method employed:

"In order to estimate the amount of actual energy generated by the oxidation of a given amount of muscle in the body, it is necessary to determine, first, the amount of actual energy generated by the combustion of that amount of muscle in oxygen, and then to deduct from the number thus obtained the amount of energy still remaining in the products of oxidation of this quantity of muscle which leave the body. Of these products, urea and uric and hippuric acids are the only ones in appreciable quantity which still retain potential energy on leaving the body, and of these the two latter are excreted in such small proportions that they may be considered as urea without introducing any material error into the results.

"These determinations were made in Lewis Thompson's calorimeter, which consists of a copper tube to contain a mixture of chlorate of potash with the combustible substance, and which can be inclosed in a kind of diving-bell, also of copper, and so lowered to the bottom of a suitable vessel containing a known quantity (2 litres) of water. The determinations were made with this instrument in the following manner: 19.5 grammes of chlorate of potash, to which about $\frac{1}{8}$ of peroxide of manganese was added, was intimately mixed with a known weight (generally about 2 grammes) of the substance whose potential energy was to be determined, and the mixture being placed in the copper tube above mentioned, a small piece of cotton thread, previously steeped in chlorate of potash and dried, was inserted in the mixture. The temperature of the water in the calorimeter was now carefully ascertained by a delicate thermometer, and the end of the cotton thread being ignited, the tube with its contents was placed in the copper bell and lowered to the bottom of the water. As soon as the combustion reached the mixture a stream of gases issued from numerous small openings at the lower edge of the bell and rose to the surface of the water, a height of about ten inches.

"At the termination of the deflagration, the water was allowed free access to the interior of the bell, by opening a stopcock con-

* Frankland, "On the Origin of Muscular Power."—"Philosophical Magazine," London, 1866, vol. xxxiii., p. 182 *et seq.*

nected with the bell by a small tube rising above the surface of the water in the calorimeter. The gases in the interior of the bell were thus displaced by the incumbent column of water, and by moving the bell up and down repeatedly a perfect equilibrium of temperature throughout the entire mass of water was quickly established. The temperature of the water was again carefully observed, and the difference between this and the previous observation determines the calorific power or potential energy, expressed as heat, of the substance consumed.

"The value thus obtained is, however, subject to the following corrections:

"1. The amount of heat absorbed by the calorimeter and apparatus employed, to be added.

"2. The amount of heat carried away by the escaping gases, after issuing from the water, to be added.

"3. The amount of heat due to the decomposition of chlorate of potash employed, to be deducted.

"4. The amount of heat equivalent to the work performed by the gases generated in overcoming the pressure of the atmosphere, to be added." *

It is evident that the determinations made in the manner above described, care being taken to make the corrections indicated, give the heat produced by the simple burning of the articles employed. As regards the heat produced by the oxidation of these substances in the body, if it is assumed that the same quantity of heat is produced by the oxidation, under all circumstances, of a definite amount of oxidizable matter, it is necessary simply to deduct from the heat-value of articles of food the heat-value remaining in the certain parts of the food which pass out of the body in an unoxidized state. It was in this way that Frankland arrived at a determination of the heat-value of articles of food oxidized in the body.

Estimated Quantity of Heat produced in the Body.—In January, 1872 Senator made an elaborate series of observations on dogs, in which he attempted to ascertain the quantity of heat produced in the body per hour per kilogramme of body-weight. The principle upon which these observations were made was essentially the same as that which underlies the experiments of Frankland on the amount of heat produced by the oxidation of alimentary matters. The animals experimented upon were inclosed in a copper cage which corresponds to

* Frankland, in Bence Jones, "Croonian Lectures on Matter and Force," London, 1868, p. 141 *et seq.*

the bell of copper in Thompson's calorimeter. The cage was supplied with a current of air, the temperature of which was carefully noted as it entered and passed out. The apparatus was immersed in a known volume of water, the temperature of which was noted at the beginning and at the close of each observation. The so-called combustion processes taking place in the body of the animals correspond to the deflagration of the alimentary substances in Frankland's experiments. The variations in the temperature of the animals and the loss of heat by the cooling of the apparatus itself were noted and used as corrections. In five experiments, the animals remaining in the apparatus for one hour in each observation, the gain in temperature of the water, all the necessary corrections being made, gave an average of 12.63 heat-units for an average weight of the animals of 5.383 kilogrammes; * that is to say, the increase in temperature of the water surrounding the cage in which the animals were inclosed was equal to 12.63° C. for each kilogramme of water. Reducing these results to the heat-units produced per kilogramme of weight of the body of the animal, there was a production of 2.34 heat-units per kilogramme of weight. The heat-unit calculated by Senator represents the raising of one kilogramme of water one degree C. One degree C. equals 1.8° Fahr. Reducing the heat-units, therefore, to the Fahrenheit scale, 2.34 heat-units equal 4.212 heat-units Fahr. As the heat-units used by Senator are per kilogramme of weight of the body and per kilogramme of water, the figures are the same when the calculation is made for a pound of water and a pound weight of the body. Reduced to heat-units representing the raising of one pound of water one degree Fahr., for each pound of weight of the body, as the result of Senator's observations, there is a production of 4.212 heat-units per hour per pound of body-weight.

In December, 1872 Dr. John C. Draper, of New York, made a series of observations on his own person, similar

* Senator, "Untersuchungen über die Wärmebildung und den Stoffwechsel."—"Archiv für Anatomie, Physiologie und wissenschaftliche Medicin," Leipzig, 1872, S. 20. In Senator's experiments estimates were made of the exhalation of carbonic acid during each observation, which I do not introduce into the discussion.

to those of Senator on dogs. In these observations he lay for one hour in a bath of a known volume of water. After making the necessary correction for the absorption of heat from the atmosphere by the water, which was $\frac{1}{2}°$ Fahr., he ascertained that he warmed "seven and one-half cubic feet of water two degrees in one hour." He estimated the volume of the body at three cubic feet, from which he calculated that "enough heat is evolved in the course of one hour to warm the body itself about five degrees of Fahrenheit's scale." * Two experiments made in this way on two successive days gave identical results. In both of these experiments, the temperature in the mouth on entering the bath was 99° Fahr. After one hour in the bath, the temperature in the mouth was 98° Fahr., showing a reduction in the temperature of the body of one degree. The temperature of the water at the beginning of the experiment was 74°. I shall assume, therefore, though this correction was not made by Draper, that of the five degrees calculated as gained by three cubic feet of water and derived from the body, one degree was due to the cooling of the body, leaving four degrees of heat actually produced by the body in the hour. A given weight of the body being capable of warming an equal weight of water four degrees Fahr. in one hour, it follows that the body produces four heat-units per pound per hour, the heat-unit representing the raising of one pound of water one degree Fahr.

The results obtained by Draper correspond very closely with those given by Senator. There is no reason to doubt the accuracy of the observations of either of these experimenters. It may be objected to Draper's experiments that the body in a bath is not under conditions absolutely physiological; but the condition of the dogs in Senator's experiments was not so abnormal as to seriously impair the value of his conclusions. In the applications which I shall make of the results of these experiments to my own observations, I shall assume that the body produces four heat-units per pound weight per hour.

In the same way it may be assumed that there is no

* Draper, "The Heat Produced in the Body, and the Effects of Exposure to Cold."—"American Journal of Science and Arts," New Haven, December, 1872.

reason to doubt the accuracy of Frankland's observations showing the heat-units produced by the oxidation of various articles of food. I shall therefore regard the determinations made by Frankland as definite propositions in the discussion which is to follow.

Conversion of Heat into Force in the Body.—In 1842 Mayer published an essay on the forces of inorganic nature, which is regarded as the starting point of the modern theories of the correlation and conservation of forces. These theories, which were at first applied to the force developed by chemical changes in inorganic matters, have recently been applied to the production of heat and the development of force in animal bodies. It is not surprising that the theory alluded to should be thus applied. Physiologists have long been seeking for an expression of the phenomena of animal heat and force in definite quantities; and they have endeavored to show that these phenomena are in accordance with certain laws which are applicable to the inorganic world. The idea of the generation or the destruction of matter is inconceivable. Matter changes its form, its characters and the arrangement of its elementary constituents; but matter itself is indestructible. It is impossible, also, to conceive of force without matter. Philosophers regarding matter as indestructible, the idea of the indestructibility of force naturally follows; and as matter undergoes changes by different arrangements of chemical elements, may there not be different kinds of manifestation of force that are interchangeable and interconvertible! The first step in the formulation of such an idea is the establishment of a unit of force which can be used to represent all dynamic manifestations; and the simplest way in which this can be expressed or defined is to measure all force by the power required to raise a certain weight a certain distance above the surface of the earth. The idea of the quantity of any force is expressed, therefore, in the raising of a given number of pounds to the height of a certain number of feet.

It is evident that the heat developed by chemical changes may be used in the production of power. Heat is commonly measured by the expansion of some substance, such as mercury, and this is reduced to the degrees of an established scale. English writers have fixed upon

a definite unit of heat, which is the heat required to raise one pound of water one degree in the Fahrenheit scale.

There are, therefore, two fixed quantities to give form to ideas of heat and force; a heat-unit, which equals one pound of water raised one degree Fahr., and a unit of force, which equals one pound weight raised one foot.

The line of reasoning adopted by Mayer is briefly the following: * An effect has a cause. Force is a cause which may produce a certain effect. A body can not fall to the earth without having been raised to the height from which it falls. The cause c has an effect e, which effect may itself act as a cause and produce a second effect f.

"If the given cause c has produced an effect e equal to itself, it has in that very act ceased to be: c has become e; if, after the production of e, c still remained in whole or in part, there must be still further effects corresponding to this remaining cause: the total effect of c would thus be $> e$, which would be contrary to the supposition $c = e$. Accordingly, since c becomes e, and e becomes f, etc., we must regard these various magnitudes as different forms under which one and the same object makes its appearance. This capability of assuming various forms is the second essential property of all causes. Taking both properties together, we may say, causes are (quantitatively) indestructible and (qualitatively) convertible objects."

The line of reasoning followed by Mayer leads him to conclude that the force exerted by a falling body ("falling force") being equal to the force which has raised the body to the height from which it has fallen, this "falling force" itself acts as a cause and produces an effect. The first cause c equals the effect e, and the effect e, acting as a cause, equals the second effect f. $c = e = f$. Consequently, $f = c$. The effect f is expressed in an elevation of temperature. The first cause c finally produces f; and as the falling of a certain weight a certain distance produces a certain quantity of heat, the heat thus produced is equal to the force required to raise the weight to the height from which it has fallen. The following are the conclusions arrived at by Mayer by this course of reasoning.

"By applying the principles that have been set forth to the relations subsisting between the temperature and the volume of gases, we find that the sinking of a mercury column by which a gas

* Mayer, "The Forces of Inorganic Nature."—"Correlation and Conservation of Forces," New York, 1868, p. 251 *et seq.*

is compressed is equivalent to the quantity of heat set free by the compression; and hence it follows, the ratio between the capacity for heat of air under constant pressure and its capacity under constant volume being taken as = 1.421, that the warming of a given weight of water from 0° to 1° C. corresponds to a fall of an equal weight from the height of about 365 metres.* If we compare with this result the working of our best steamengines, we see how small a part only of the heat applied under the boiler is really transformed into motion or the raising of weights; and this may serve as justification for the attempts at the profitable production of motion by some other method than the expenditure of the chemical difference between carbon and oxygen—more particularly by the transformation into motion of electricity obtained by chemical means."

In an essay on the "Correlation of Physical Forces," by Grove, is a very clear and succinct account of the experiments of Joule,† whose results are those most generally adopted and used at the present day:

"Mr. Joule has made a great number of experiments for the purpose of ascertaining what quantity of heat is produced by a given mechanical action. His mode of experimenting is as follows: An apparatus formed of floats or paddles of brass or iron is made to rotate in a bath of water or mercury. The power which gives rise to this rotation is a weight raised like a clock-weight to a certain height; this by acting during its fall on a spindle and pulley communicates motion to the paddle-wheel, the water or mercury serving as a friction medium and calorimeter; and the heat is measured by a delicate mercurial thermometer. The results of his experiments he considers prove that a fall of 772 pounds through a space of one foot is able to raise the temperature of one pound of water through one degree of Fahrenheit's thermometer. Mr. Joule's experiments are of extreme delicacy—he tabulates to the thousandth part of a degree of Fahrenheit, and a large number of his thermometric data are comprehended within the limits of a single degree. Other experimenters have given very different numerical results, but the general opinion seems to be that the numbers given by Mr. Joule are the nearest approximation to the truth yet obtained." ‡

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* The above reduced to a degree of Fahrenheit and to feet gives the following: One heat-unit Fahrenheit, or one pound of water raised one degree Fahrenheit, equals one pound weight raised to the height of 665 feet, or 665 foot-pounds.

The following note is added by the translator of Mayer's essay:

"When the corrected specific heat of air is introduced into the calculation this number is increased, and agrees then with the experimental determinations of Mr. Joule."

† Joule's original essay is in the "Philosophical Transactions," 1850, p. 61, and is entitled "On the Mechanical Equivalent of Heat."

‡ Grove, "Correlation of Physical Forces."—"The Correlation and Conservation of Forces," New York, 1868, p. 33.

I have thus given as plain a statement as I can make of the experiments on which the prevailing theories of the mechanical equivalent of heat are based. The experimental fact involved is the production of heat by force. Algebraically, the equations seem unquestionable. Cause = effect; effect acting as a second cause = a second effect, which is heat; consequently the first cause, which is a definite amount of force, = the second effect, which is a definite amount of heat, and conversely the heat = the force. The experimental demonstration is the production of a certain quantity of heat by falling force, but never the production of the same amount of force by the heat. One can readily understand how there must be, in machinery constructed to produce force by heat, as in a steam engine, such a waste of heat as to actually give much less available force than is really equivalent to the heat employed. Viewed in this way, the question rests within the province of pure physics; but when the law of the correlation and conservation of forces is applied to animal mechanics, it is not difficult to see that the argument is one-sided. The operations involved in the theory under consideration are two; viz., the production of animal heat and muscular force, the latter including the force used in circulation and in the movements of respiration. In animal mechanics, heat is not produced by force; but it is the theory that force results from a transformation of the heat remaining after sufficient heat has been produced to keep up the constant animal temperature. According to the present theory, physiologists must always reason in one direction, from the transformation of heat into force, while the physical basis of the theory consists of experiments in an opposite direction, the transformation of force into heat. Looking at the question in its relations to physiology, while I can not say that in an equation, if $a = b$, the converse, $b = a$, is not a self-evident proposition, I am not prepared to admit, without some experimental proof, the theory that one heat-unit produced in the animal body is equivalent to 772 foot-pounds of force. I fully appreciate the temerity of an expression of want of perfect faith in the doctrine of the convertibility of a certain quantity of heat into a definite quantity of force in animal bodies. It is enough to say that this view is

accepted by Helmholtz, Faraday, Liebig, Carpenter, and, indeed, by nearly all modern philosophers. But, will this theory accord with all established physiological facts? This is the question that I propose to discuss, carefully considering the experimental basis of the facts that I shall bring forward, and allowing, in my discussion of these facts, for all elements of possible error and inaccuracy.

The experiments of Frankland show that certain articles of food, when oxidized, produce a certain quantity of heat. It may be assumed that the heat thus produced will always be the same whether the oxidation be slow or rapid. Animal heat and the force exerted by the body must be derived, directly or indirectly, from food. The quantity of food taken within a certain time can be measured and the heat-value of such food may be determined. If the food taken can be shown to possess a heat-value which is manifestly in excess of the total ascertainable heat and force developed in the body, one can understand how a certain quantity may pass away in such a manner that it can not with certainty be determined how it is lost. Experimental methods in physiology are not so exact as to enable investigators to follow all the changes which take place in the body. But if, on the other hand, the estimated heat-value of food should fall far short of accounting for the heat and force generated in the body, there would seem to be an error either in the law or in its application.

Experiments have been made by precisely the same methods as those by which the heat-value of articles of food has been established, showing that a warm-blooded animal or a man produces a certain quantity of heat per hour per pound weight of the body. These experiments I have already discussed. There is no more reason to doubt their accuracy than there is to question the results of the experiments of Frankland on the heat-value of articles of food. In order to show that the application of the law of the relations between heat and force to animal mechanics is correct and that the law itself is correct, one must, as a logical necessity, be able to account for the heat and force developed in animal bodies by the heat-value of food or of body-weight consumed when the food is insufficient. If observers have correctly estimated

the heat-value of food, and have also correctly estimated the heat and force developed in the body, there must be an error in the calculated relations between heat and force, if physiological facts do not sustain the theory.

Observation I.—In 1870 I had occasion to note the work, the quantity of food taken and various other conditions in a healthy man for several consecutive days. The observations were made at that time with another object in view; but the data obtained will serve in the present argument. I shall here make use of the estimates made for five consecutive days.

During the five days, the total nitrogen in the food was 1,173.82 grains. It is estimated by Dr. Pavy,* according to the observations of Frankland, that one ounce (437.5 grains) of dry albuminous matter, as consumed within the body, is equal to 165.20 foot-tons of force. Dr. Pavy computes, from Mulder's analysis, that 15.5 is the percentage of nitrogen in dry albuminous matter. According to this computation, 1,173.82 grains of nitrogen represent 7,573.03 grains, or 17.31 ounces of dry albuminous matter. During these five days, there was a loss of body-weight of 3.45 pounds. The subject of the experiment walked 317½ miles in the five days, and, at the beginning of the walk, had no appreciable fat. I therefore estimated the loss of weight as muscular tissue and calculated it as equal to 724.5 grains of nitrogen, equivalent to 4,674.20 grains, or 10.68 ounces of dry albuminous matter.† The total force-value, then, of nitrogenous food and of loss of body-weight (27.99 ounces of dry albuminous matter) was 4,623.95 foot-tons, or 10,357,648.00 foot-pounds, equal to 13,416.64 heat-units.

I carefully estimated, for the five days, the heat-value of the non-nitrogenous food (milk, bread, oatmeal, potatoes, butter, and sugar). The heat-value of this food, calculated from Frankland's tables, amounted to 19,521.41 heat-units.

The following gives the total heat-value of the food and loss of body-weight for five days:

	Heat-units.
Nitrogenous food and loss of body-weight...........	13,416.64
Non-nitrogenous food............................	19,521.41
Total sources of heat give..........................	32,938.05

The observations of Senator on dogs and those of Draper on his own person show that the actual quantity of heat produced by the body is equal to at least four degrees Fahr. per pound weight per hour, which gives ninety-six degrees per pound weight for twenty-four hours. The subject of my observations had an average weight, for five days, of 115½ pounds. He consequently produced 11,088 heat-units in twenty-four hours, and 55,440 heat-units in the five days. The estimate of four degrees per pound per hour is for repose. If this estimate is correct for repose, the sub-

* "The Lancet," December 16, 1876, p. 849.

† According to Payen, lean meat, uncooked, or muscular tissue, contains three per cent. of nitrogen. (Payen, "Substances alimentaires," Paris, 1865, p. 488.)

ject of my experiment must have produced much more heat during the exertion of walking 317½ miles in five days. Taking the estimate of four degrees, however, gives the following:

Heat-units produced by the body in five days........	55,440.00
Heat-value, in heat-units, of food and loss of body-weight..	32,938.05
Heat-units unaccounted for...	22,501.95

In the above calculation, no account is taken of the force exerted in walking 317½ miles or of the force employed in circulation and respiration. The estimates of the force used in circulation and respiration are of necessity approximate. According to Letheby, it equals about 600,000 foot-pounds per day,* or 3,000,000 foot-pounds in five days, which equal 3,886.00 heat-units. It is more difficult still to estimate the force used in walking 317½ miles. An estimate has been made, however, of the force used in walking on a level, by Haughton. This estimate is that the work accomplished is equal to raising one-twentieth of the weight of the body through the distance walked, assuming the rate of speed to be three miles per hour.† For sake of argument I shall use this estimate, although I have little confidence in its accuracy and the rate of speed in walking the 317½ miles was between four and one-half and five miles per hour instead of three miles. The force, then, in walking 317½ miles was equal to 4,321.33 foot-tons, equivalent to 12,538.57 heat-units. Taking all of these estimates, the total heat-units expended in five days would be as follows:

Heat-units produced (animal heat)..................	55,440.00
Heat-units converted into force, expended in walking 317½ miles (estimated).........................	12,538.57
Heat-units converted into force expended in circulation and respiration (estimated)..................	3,886.00
Total expended in five days......................	71,864.57
Total heat-units derived from all kinds of food and from loss of body-weight.........................	32,938.05
Unaccounted for................................	38,926.52

Taking the heat produced by the body in maintaining the standard temperature for five days as 55,440.00, and the total heat-value of all kinds of food and of loss of body-weight as 32,938.05, about forty per cent. of the heat actually produced can not be accounted for in the estimates that I have given. Adding to the heat produced by the body the estimated heat-units converted into force and used in walking 317½ miles and in keeping up circulation and respiration, there is a total of 71,864.57 heat-units, of which about fifty-five per cent. can not be

* Letheby, "On Food," New York, 1872, p. 96.
† Haughton, "Principles of Animal Mechanics," London, 1873, p. 57.

accounted for by the estimated heat-value of the food and of the loss of body-weight.*

It is well known that in a machine, like a steam engine, but a small fraction of the calculated value of the heat employed can be actually used or measured as force. As regards this, the explanation that a large quantity of heat is necessarily wasted is satisfactory. But suppose, instead of this, the steam engine burned coal, the heat-value of which was equal to 12,000 heat-units, and produced thereby force represented by 20,000 heat-units, leaving 8,000 heat-units, or forty per cent. of the force actually produced, unaccounted for. In the face of such a demonstration, the theory that one heat-unit equals 772 foot-pounds would fall to the ground. Provided the experiments are correct, the same process of reasoning may properly be applied to the physiological problem. I start with the assumption that the oxidation of a definite amount of matter produces a definite amount of heat, be the process slow or rapid or be it in the animal machine or in a calorimeter. All food has a determinable heat-value. But the heat-value of the food compared with the heat actually produced in the body in a given time leaves forty (five?) per cent. of the heat actually produced which can not be accounted for. This large deficiency demonstrates the existence of some error which may be expressed in one or more of the following propositions:

I. There may be an error in calculating the heat-value of the articles of food.

II. It may be an error to assume that the heat-value of the changes which the food undergoes in the body is equal to the heat-value as calculated by experiments with the calorimeter.

III. There may be an error in the estimates of the amount of heat actually produced by the body.

Suppose, again, that I add to the heat used in maintaining the temperature of the body the heat converted into

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* At the present time (1902) I have adopted two and a half instead of four heat-units per pound weight per hour. This would make a large difference in these calculations. In this paragraph, instead of about forty per cent., the heat unaccounted for should be about five per cent.; and instead of about fifty-five per cent., it should be about thirty-seven and a half per cent. The estimate of heat produced, however, I still regard as very uncertain. See also Article XXIV., "Remarks on Fever."

force required for work. There remain, of the heat-units required for all these processes, fifty-five (thirty-seven and a half?) per cent. unaccounted for. Added to the errors to be looked for in reasoning from the animal heat alone and taking no account of the work, there are possible errors which may be expressed in the following propositions:

I. It may be an error to assume that the value of the transformation of one heat-unit into force in the body is equal to 772 foot-pounds.

II. There may be an error in the formula by which the work of walking on a level is reduced to foot-pounds.

III. There may be an error in the estimate of the force used in circulation and respiration.

Observation II.—November 22, 1878, I began the following experiment, in which I fasted for twenty-four hours:

November 22.—5.10 P. M., I had an alvine dejection. 6.45 P. M., I dined heartily. 10.45 P. M., I ate three poached eggs and toast and drank half a pint of Bass's ale. I slept well during the night.

November 23.—7.45 A. M., I emptied the bladder but failed to have a passage from the bowels. 8 A. M., I began my observations, having taken no food since 10.45 P. M. of November 22. My body-weight, without clothing, was $188\frac{1}{4}$ pounds. The temperature under the tongue, taken for five minutes, was 99° Fahr. I walked half a mile. 9 A. M., I drank 8 fluidounces of water. 10 A. M., I played at billiards for two and one-half hours and drank 8 fluidounces of water. 1.30 P. M., I walked a quarter of a mile. 2 P. M., hunger was quite distressing, but it was relieved by smoking. 3.30 P. M., I walked about a quarter of a mile. 4 P. M., I had hardly any sense of hunger. The temperature under the tongue, taken for five minutes, was $98\frac{5}{8}$° Fahr. 5.30 P. M., I played at billiards for one hour. 7.30 P. M., I drank 4 fluidounces of water. I went to the theatre in the evening and walked about a quarter of a mile. 11.15 P. M., the temperature under the tongue, taken for five minutes, was $99\frac{5}{8}$° Fahr. I slept rather uneasily during the night.

November 24.—7.45 A. M., I emptied the bladder but could not secure an operation of the bowels. 8 A. M., the experiment was concluded. The body-weight without clothing was $184\frac{3}{4}$ pounds. The temperature under the tongue, taken for ten minutes, was $97\frac{3}{4}$° Fahr. I had fasted for about thirty-three hours, but I calculated the fast from 8 A. M., November 23, to 8 A. M., November 24, for twenty-four hours after digestion had probably been completed. I suffered from hunger only at about 11 A. M., 2 P. M., and 7 P. M., the hours when I habitually took food. The suffering from hunger was less than I had anticipated and was much relieved by smoking three cigars during the day, smoking very frequently and but little at any one time. It is proper to state that I am forty-two years of age, five feet ten and one-half inches in height and that I have been in the habit of daily muscular exercise in a gymnasium for the

past ten years. I have a rather unusual muscular development. The weather had been fair and partly cloudy, with a temperature of $45\frac{1}{4}°$ Fahr., an average of eight observations.

The urine passed during the day was collected and analyzed with the following results:

Total quantity 34 fluidounces. Reaction acid; color and odor normal; specific gravity $1023\frac{1}{2}$; no albumin; no sugar; nothing abnormal on microscopical examination.

An analysis of the urine was made by Dr. C. A. Doremus for urea and uric acid. The urea was estimated by Liebig's process, the standard solution having been carefully titrated with pure urea. The uric acid was estimated by treating the urine for forty-eight hours with hydrochloric acid, all corrections being carefully made. The results of these examinations were as follows:

Urea, 14.78 grains per fluidounce = 502.52 grains in twenty-four hours = 234.51 grains of nitrogen. Uric acid, 0.255 of a grain per fluidounce = 8.67 grains in twenty-four hours = 2.89 grains of nitrogen.

The total quantity of nitrogen contained in the urea and uric acid eliminated in the twenty-four hours was 237.4 grains. It is estimated by Dr. Pavy, according to Frankland's observations, that one grain of urinary nitrogen is equivalent to an amount of nitrogenous tissue consumed which would produce 2.4355 foot-tons of force, or 7.067 heat-units.* The 237.4 grains of urinary nitrogen, therefore, would be equivalent to 1,677.70 heat-units.

It is important, in following out the course of reasoning that I have attempted, to form an idea of the avenues of escape of the matter represented by the loss of body-weight during the twenty-four hours of abstinence from food. There was no passage from the bowels, and the loss of weight, therefore, must have taken place by the urine, skin and lungs. The total loss of weight was 56 ounces; the water taken was 20 ounces, making 76 ounces; I passed 34 ounces of urine of a specific gravity of $1023\frac{1}{2}$, the actual weight of which was 36 ounces. This leaves an actual loss of weight, deducting the weight of the urine, of 40 ounces. This 40 ounces must have escaped by the lungs and skin in the form of carbonic acid and water. No account was taken, in the experiment, of the actual quantity of carbonic acid eliminated, and this I was forced to estimate. It is stated by Dr. Edward Smith, as the result of observations upon four persons whose average weight was 160 pounds, that the total quantity of carbon eliminated in twenty-four hours in a condition of perfect

* "The Lancet," December 16, 1876, p. 849.

rest was 7.144 ounces.* This is equivalent to about 8.327 † ounces for a weight of 186½ pounds, which was the mean weight for the day. Deducting the estimated carbon eliminated from 40 ounces, there was an elimination of a little less than 32 ounces of water by the pulmonary and cutaneous surfaces. This is less than the estimates given in most works on physiology but the difference is not very great.‡ Returning to the elimination of carbon, it is estimated that one ounce of dry fat contains 345.6 grains of carbon.# An elimination, therefore, of 8.327 ounces of carbon would represent 10.541 ounces of dry fat. According to Frankland,‖ the heat-value of 10.541 ounces of fat is equal to 10,759.09 heat-units.

From these calculations for twenty-four hours of fasting, the following sources of heat are estimated:

	Heat-units.
Heat-value of 237.4 grains of urinary nitrogen	1,677.70
Heat-value of 10.54 ounces of fat	10,759.09
Total	12,436.79

Estimating the heat produced by the body at four degrees per pound per hour, for a weight of 186½ pounds:

	Heat-units.
Produced in twenty-four hours	17,904.00
Deduct	12,436.79
Unaccounted for by urinary nitrogen and carbon excreted	5,467.21

If it is assumed that the estimate of the heat-value of the urinary nitrogen is correct as well as the heat-value of the probable exhalation of carbonic acid, and also

* Edward Smith, "Experimental Inquiries into the Chemical and other Phenomena of Respiration."—"Philosophical Transactions," London, 1859, p. 692.

† In calculating the loss of weight by the lungs and skin, it is proper to estimate the weight of carbon eliminated instead of the weight of carbonic acid, for the reason that the carbon comes from the body and the oxygen which unites with it to form carbonic acid comes, at least indirectly, from the air. Supposing that a certain quantity of the oxygen of the air unites with hydrogen to form water which is thrown off, the weight of this oxygen should be deducted from the water; but experiments are wanting to show the quantity of oxygen which combines in this way, and such a correction could not be made with any reasonable degree of accuracy.

‡ Valentin estimates the average pulmonary exhalation at about 19 ounces (Flint, "Physiology of Man," New York, 1875, vol. i., p. 447). The estimate of the cutaneous transpiration is about 30 ounces (*Ibid.*, vol. iii., p. 139). Taking into account the season of the year and the slight exercise with the small quantity of water taken, the estimate of 32 ounces for both the pulmonary and the cutaneous exhalation seems to be reasonable.

Pavy, "Food and Dietetics," Philadelphia, 1874, p. 440, quoted from Parkes.

‖ Letheby, "On Food," New York, 1872, p. 94.

that the estimated heat produced by the body is reasonably accurate, a little less than one-third (?) of the heat produced during the twenty-four hours of fasting can not be accounted for by the heat represented by the urinary nitrogen and carbon eliminated.

This experiment, in which absolutely no food was taken, possesses many points of advantage. In such an experiment, but three matters discharged from the body demand serious consideration; viz., urinary nitrogen, carbonic acid and water. It is possible to calculate the quantity of nitrogenous matter of the body represented by the urinary nitrogen and the quantity of fat represented by the carbonic acid discharged and estimate their heat-value. The only thing that remains is the water. From the estimates that have been made, there remain about 5,500 (?) heat-units that can not be accounted for by any heat-producing processes in the body represented by discharge of urea and carbonic acid. I have estimated that about 32 ounces of water are lost during the day by the lungs and skin. Of this 32 ounces, one-ninth, or 3.55 ounces, consists of hydrogen. It is estimated that one kilogramme of hydrogen will produce 34,600 heat-units C.,* and one pound, the same number represented in pounds, or 62,280 heat-units Fahr. The heat-value, then, of one ounce of hydrogen would be 3,892.5 heat-units, or 13,818,375 heat-units for 3.55 ounces. If it could be shown that water is actually produced in the body by a union of hydrogen and oxygen, and that a sufficient quantity of oxygen is not returned to the air in the form of carbonic acid to combine with even one or two ounces of hydrogen, it would be possible to account, not only for the heat actually produced in the body, but for the heat assumed to be converted into force to carry on circulation, respiration and ordinary muscular work.

Observation III.—November 30, 1878, one week after the date of Observation II., having entirely recovered from the effects of the previous experiment, I began the following observation, in which the quantity and the heat-value of food taken for twenty-four hours were carefully noted and calculated.

At 8 A. M., I had a passage from the bowels. The weight of

* Mayer, "Celestial Dynamics."—"Correlation and Conservation of Forces," New York, 1868, p. 261.

the body taken just afterward, without clothing, was 186¼ pounds. The temperature under the tongue, taken for five minutes, was 98° Fahr.

At 8.45 A. M., I breakfasted as follows, taking each article from a separate plate which was weighed before and after eating:

Lean beefsteak, 10 ounces, with bread, butter and milk. The bread, butter and milk were calculated for the twenty-four hours, and the bread-crumb only was taken, without the crust.

At 1 P. M., I took a lunch of lean roast-beef, 6 ounces; boiled potatoes, 3.5 ounces, with bread-crumb, butter and milk.

At 5.30 P. M., the temperature under the tongue, taken for five minutes, was 99¾° Fahr.

At 6.45 P. M., I dined on lean roast-beef, 10 ounces; fried potatoes, 3 ounces; Bass's ale, 24.5 ounces by weight, with bread-crumb and butter.

At 12, midnight, the temperature under the tongue, taken for five minutes, was 100° Fahr. I retired and slept well during the night.

At 8 A. M., December 1, I had a passage from the bowels. The body-weight taken just afterward, without clothing, was 186¼ pounds, exactly the weight at the beginning of the experiment. The temperature under the tongue, taken for five minutes, was 98¼° Fahr. During the twenty-four hours, I had taken 10 ounces of bread-crumb, 3.75 ounces of butter and 34.5 ounces of milk. The weather had been fine, with a temperature of 42⅞° Fahr., an average of eight observations. I had eaten of the articles indicated all that I desired. During the day I walked about two miles, played at billiards for about three hours and smoked five cigars. A calculation of the heat-value of the food was made by the following table reduced to ounces, from Letheby,* and carefully corrected from the original tables of Frankland:

HEAT-UNITS PER OUNCE AV. OF THE FOLLOWING ARTICLES OF FOOD OXIDIZED IN THE BODY

Beef (lean)	160.12
Bread-crumb	241.50
Potatoes	112.00
Butter	817.25
Milk	71.75
Bass's ale (alcohol reckoned)	87.06

According to this table the following was the heat-value of the food taken in the twenty-four hours:

	Heat-units.
Beef, 26 ounces	4,163.12
Bread-crumb, 10 ounces	2,415.00
Potatoes, 6.5 ounces	728.00
Butter, 3.75 ounces	3,064.69
Milk, 34.5 ounces	2,475.37
Ale, 24.5 ounces	2,132.97
Total heat-value of food	14,979.15

* Letheby, "On Food," New York, 1872, p. 94.

Estimating the production of heat by the body as equal to four heat-units per pound per hour:

	Heat-units.
Produced in twenty-four hours......................	17,880.00
Heat-value of food.............................	14,979.15
Unaccounted for by the heat-value of food..........	2,900.85

This calculation leaves about one-sixth of the heat produced by the body unaccounted for by the heat-value of the food taken.*

Possible Oxidation of Hydrogen in the Body, resulting in the Formation of Water and the Production of Heat.—It is by no means a novel idea that oxygen may unite with hydrogen in the body to form water and produce heat; † but thus far there has been no experimental demonstration of the actual production of water in the animal economy. In the experiment in which I fasted for thirty-three hours, for twenty-four hours of which no food was taken after the digestion of articles taken about nine hours before had been completed, I discharged about 32 ounces of water by the lungs and skin, and 34 ounces of water in the urine, making a total discharge of water of 66 ounces. During this period I drank 20 ounces of water, leaving 46 ounces over and above the quantity taken. My loss of weight was 56 ounces, of which I estimate a loss of about 10 ounces in solid matters in the urine and carbon by the lungs. The question now is whether this loss of 46 ounces of water was simply a discharge of water already formed from the blood and the water parts of the tissues or whether it is to be attributed in part to water actually formed in the body by a union of oxygen and hydrogen. When the watery parts of the body are actually deficient in quantity there is a sensation of thirst. I did not suffer from thirst, and, indeed, I drank rather more water than I desired. Recent experiments by Valentin, Panum, Colin and others, have shown, in opposition to previously received opinions, that abstinence from food has very little effect in diminishing the volume

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* See foot-note, p. 71. Estimating the production of heat by the body at two and a half heat-units per pound per hour, the deficiencies in the heat-values of weight, food taken etc., do not exist. See also Article XXIV., "Remarks on Fever."

† In 1780 and 1785, Lavoisier and Laplace advanced the view that animal heat was produced by the oxidation of carbon and hydrogen in the body.

of the blood.* This fact, taken in connection with the absence of thirst during the twenty-four hours of fasting, is favorable to the view that all the excess of water discharged did not come directly from the blood.

If water is produced in the economy by a union of oxygen and hydrogen, what is the probable source of these two elements? There is no deficiency of hydrogen in the body, and if it is used to form water which is discharged there would be loss of weight when no food is taken, and it would be supplied by the food, under ordinary conditions of nutrition. There is no deficiency of oxygen in the body itself, and the oxygen discharged in urea represents only about one-third of the oxygen contained in the nitrogenous constituents of the body. Of the oxygen taken into the lungs, about 86 per cent. only is returned in combination with carbon to form carbonic acid, leaving 14 per cent. to form some other combination in the body, possibly a union with hydrogen. There is, indeed, little or no difficulty in accounting for the elements to form water, if it can be shown that more water is discharged from the organism than is taken with the ingesta, and that the excess thus discharged does not come simply from the watery parts, producing an actual deficiency of water in the body.†

The actual demonstration that more water is ever discharged from the body than can be accounted for by the water of the ingesta or by water simply withdrawn from the blood and rendering this fluid more dense presents very considerable but not insurmountable difficulties. A process that would be open to few objections, provided all the elements used in the calculations were accurate, is the one which I have attempted to employ in cases of loss of weight. This process is the following:

Take the weight of a man at the beginning of the experiment, calculate accurately the weight of the ingesta for a certain period and add this latter to the weight of the body. This forms the sum total from which certain

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* Robin, "Leçons sur les humeurs," Paris, 1874, p. 50.

† Funke, "Lehrbuch der Physiologie," Leipzig, 1876, Bd. i., S 297. I have quoted from Funke the results obtained by Pettenkofer and Voit, and have taken as an average of their results, 833 grammes of oxygen consumed and 985.2 grammes of carbonic acid produced in twenty-four hours. 985.2 grammes of carbonic acid represent 716.5 grammes of oxygen.

quantities are to be deducted. Take then the weight of the urine and feces passed during the time of the experiment; add to this the weight of carbon contained in the carbonic acid exhaled, which carbon carries with it a portion of the inspired oxygen; add both of these to the weight of the body taken at the close of the experiment; the difference will give the quantity of water discharged by the lungs and skin. Having thus the quantity of water discharged by the lungs and skin, in order to ascertain the total quantity of water discharged from the body, the water contained in the urine and feces must be added. The water contained in the ingesta may then be estimated and compared with the quantity of water discharged. In Pettenkofer's chamber, in which a man may be confined and all the excreta be estimated, these calculations could be made with sufficient accuracy; and the only uncertain element in the problem would be as to whether or not the blood became modified in density or volume. In the following calculation, I was forced to estimate the amount of carbon eliminated; but I endeavored to correct this estimate by an indirect method, which will be described farther on. The subject of my experiment was the person mentioned in Observation I., and the investigations described were continued for five days. The following is a summary of the results:

Observation upon the Ingress and Egress of Water

		Ounces.
Body-weight at the beginning of the observation..		1,907.20
Weight of the ingesta for five days		857.34
Total		2,764.54
Weight of the urine and feces for five days	220.47	
Carbon eliminated for five days, estimated at 10 ounces per day*	50.00	
Body-weight at the end of the five days (showing a loss of 55.2 ounces)	1,852.00	
	2,122.47	2,122.47
Water eliminated by the lungs and skin		642.07
Water contained in the urine and feces		208.89
Total water discharged		850.96

* As I have stated in the text, I was forced to estimate the amount of carbon discharged, but I preferred to put it too high rather than too low. Ten ounces per day is a very high estimate for a man weighing 115½ pounds. The

WATER OF THE FOOD FOR FIVE DAYS

Articles of Food.	Quantity. Ounces.	Quantity Water. Ounces.
Meat	23.87	16.95
Eggs	27.60	17.31
Milk	36.03	31.34
Bread	28.87	12.70
Beef-essence	42.13	40.03
Oatmeal-gruel	18.09	17.19
Potatoes	5.00	4.38
Butter	4.88	0.73
Coffee	287.09	278.48
Tea	124.25	123.01
Water	11.75	11.75
Lemonade	227.16	227.16
Molasses and water	4.40	4.18
Tomatoes	3.12	2.97
Sugar, salt, pepper, bicarbonate of potash	12.10	
	857.34	788.18
Total water discharged in five days		850.96
Total water ingested in five days		788.18
Excess of water discharged in five days		62.78
Excess of water discharged per day		12.56

The heat-value of the hydrogen required to form one ounce of water is equal to 432.5 heat-units. The heat-value, then, represented by the formation of 12.56 ounces of water would be 5,432.2 heat-units.

One of the observations in which I calculated the quantity of water discharged as compared with the quantity ingested was for twenty-four hours of abstinence from food. (See Observation II.) The other was for a person who lost considerable weight as the result of excessive muscular work. Even when no food is taken, a certain quantity of heat must be produced, and the standard animal temperature must be maintained. The heat thus produced can easily be accounted for by the carbon discharged in

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following indirect calculation of the probable sources of carbon shows that this estimate certainly is sufficient. I calculate the total carbon of the food as about 25 ounces. To this I add the carbon of 48 ounces of muscular tissue consumed (5.28 ounces), and of 7.2 ounces of fat, both loss of weight (5.69 ounces). This gives about 36 ounces of carbon for five days. From this I deduct 9 ounces of carbon discharged in the urea, which leaves 27 ounces for five days, or 5.4 ounces per day. If I calculated that the entire loss of weight of 55.2 ounces should be estimated as fat—which is very improbable from the condition of the subject on beginning the walk, and the discharge of a considerable quantity of nitrogen from the body over and above the nitrogen of food—there would be about 59 ounces of carbon for five days, or 11.8 ounces per day. The last-named quantity would make very little difference in the results.

carbonic acid with the hydrogen discharged in water; and it seems reasonably certain that water is actually formed in the body. Under excessive exercise attended with loss of weight, it seems certain that water is produced in the body by a union of hydrogen and oxygen. Animal heat is undoubtedly produced very largely by oxidation; and it has been shown that muscular work, while it has a tendency to raise the animal temperature, very considerably increases the elimination of water.* The chemical products of this oxidation are represented mainly by urea, so far as nitrogen is concerned, and by carbonic acid and water. There are thus three elements with which the oxygen combines; viz., nitrogen, carbon and hydrogen. If it is not possible to account for the total quantity of heat produced in the body by the urea and carbonic acid discharged, this can be accounted for by supposing that a certain quantity of hydrogen is oxidized in the body to form water.

I do not pretend to assert that the oxygen absorbed by the blood in its passage through the lungs forms a direct and immediate union with carbon and hydrogen to form carbonic acid and water. If such a union takes place, carbonic acid and water are the final products resulting from a series of molecular changes, the various steps of which physiologists are as yet unable to follow; but probably it is true that if a union of oxygen with carbon and hydrogen will produce a definite quantity of heat the quantity of heat is the same, be the combination slow or rapid. As regards the oxidation of carbon and hydrogen, all that it is necessary to show is that carbonic acid and water are actually produced in the body, as a part of the final results of the intricate molecular changes involved in nutrition and disassimilation. There is no good reason to suppose that the processes of physiological wear or disassimilation of the tissues are radically changed in their character during a short period of abstinence from food or during exercise which for a time wastes the tissues more rapidly than

* Pettenkofer and Voit, as one of the conclusions arrived at by experiments upon a man twenty-eight years of age, kept for twenty-four hours in their large respiration-apparatus, make the following statement: "The elimination of water is very much increased by work, and the increase continues during the ensuing hours of sleep."—"Journal of Anatomy and Physiology," Cambridge and London, 1868, vol. ii., p. 181.

they can be repaired. When the appropriation of nutritive matters produces an equilibrium between the physiological waste and repair, it is logical to conclude that the waste of the tissues, which involves the oxidation of a certain quantity of carbon, nitrogen and possibly hydrogen, is repaired by the food, the nature of the processes involved in the waste being the same as during a period of abstinence from food. As regards, therefore, the oxidation of hydrogen, it is probable that the hydrogen of the non-nitrogenous parts is consumed, and that the matter thus consumed is supplied again to the tissues in order to maintain the physiological status of the organism.

The supposition that water may actually be formed within the organism under certain conditions not only completes the oxidation-theory of the production of animal heat, but it explains certain physiological phenomena that have heretofore been obscure. It is well known, for example, that a proper system of physical training will reduce the fat of the body to a minimum consistent with health and strength. This involves a diet containing a relatively small proportion of fat and liquids, and regular muscular exercise attended with profuse sweating. It has been seen that muscular work increases the elimination of water, while it also exaggerates for the time the calorific processes. Muscular exercise undoubtedly favors the consumption of the non-nitrogenous parts of the body, and a diminution of the supply of carbohydrates, fats and water in the food prevents, to a certain extent, the new formation of fat. The ingestion of a large quantity of liquid does not increase the calorific processes or promote activity of the circulation; and the excess of water usually is discharged by the kidneys. When, however, there is excessive exercise of the muscular system, the production of water is increased and the circulation becomes more active. The volume of blood then circulating in the skin and passing through the lungs in a given time is relatively increased, and there is an increased discharge of water from these surfaces. The same condition that produces an increased quantity of water in the body and has a tendency to exaggerate the process of calorification seems to produce also an increased evaporation from the surface, which serves to equalize the animal temperature. It is

stated by Maclaren that in one hour's energetic fencing, the loss by perspiration and respiration, taking the average of six consecutive days, was about three pounds, or accurately, forty ounces, with a varying range of eight ounces.*

CONCLUSIONS

I shall restrict the conclusions to be drawn from my experiments to points connected with the production of animal heat. It is undoubtedly true that computing all the force produced in the body as heat-units, more heat is generated than is absolutely necessary to maintain the normal animal temperature, and that a certain part of this excess is converted into force used in the work of respiration and circulation and general muscular effort. The computation of the force thus used is made in accordance with the formula that one heat-unit is equivalent to 772 foot-pounds. The reduction of the force of the heart and the force exerted by the respiratory muscles to units of foot-pounds is so uncertain that the estimates given by writers are, in my opinion, almost worthless. The same remark applies to the reduction of ordinary muscular work to definite units. Without some such reduction, the force exerted by muscles can not be accurately expressed in definite quantities. All that can be done is to show, if possible, that more heat-units are produced in the body than are required to maintain the heat of the body, and that a part of the excess is converted into force.

My own experiments were made under certain disadvantages. While it was not difficult to collect the urine and feces and to estimate the constitution of the food, I had no apparatus that would have enabled me to ascertain exactly the quantities of oxygen absorbed and of carbonic acid exhaled for a number of hours. With such an apparatus as Pettenkofer's respiration-chamber, it would be possible to make accurate estimates of the oxygen absorbed and carbonic acid and water excreted, and thus it might be shown whether or not water can be produced in the body; and if it could be demonstrated that water may be thus produced, it could be ascertained what proportion of such water was probably produced by a union

* Maclaren, "Training, in Theory and Practice," London, 1866, p. 89.

of a portion of the inspired oxygen with hydrogen, by simply deducting the oxygen used in the production of carbonic acid from the total quantity consumed. Still, taking my experiments as they are and connecting them with what had been previously ascertained in regard to the questions under consideration, I think I am justified in drawing from them the following conclusions:

I. It is probable, and indeed almost certain, that nearly all the animal heat is produced by oxidation, in the body, of certain elements, which are chiefly nitrogen, carbon and hydrogen.

II. It is probable that this oxidation does not take place entirely in the blood, but that its seat is in the substance of the various tissues and that it is connected with the general processes of nutrition and disassimilation. Heat is thus evolved, and the final products of the chemical action are mainly urea, carbonic acid and water. It must be remembered, however, that the oxidation is not necessarily a process identical with simple combustion out of the body, but that it probably is connected with a series of intricate molecular changes, which cease with the life of the tissues and of which physiologists are able to recognize only the final results; viz., calorification and certain chemical products.

III. Recognizing the products, urea, carbonic acid and water, as representing the evolution of a certain quantity of heat, if it is admitted that hydrogen is oxidized in the body, resulting in the evolution of heat and the production of water, the sum of the changes involved will account for all the heat actually manifested as heat, leaving an excess which may be converted into force.

IV. My experiments show pretty clearly that, when no food is taken and when, food being taken, muscular work is done, so that there is loss of body-weight, water is produced in the body. This renders it possible to account for all the heat evolved under these conditions. There is no reason to suppose that the processes involved in the production of heat are radically changed in their character when enough food and water are taken to maintain a uniform body-weight.

V. Animal heat is produced mainly by oxidation of the nitrogen, carbon and hydrogen of the tissues, the con-

sumption of these elements being supplied by the food. Probably the oxidation of carbon and hydrogen is a more important factor in calorification than the oxidation of nitrogen; at least it is certain that the heat-value of the oxidation of carbon and hydrogen is greater than that of the oxidation of nitrogen, and the quantity of heat thus produced is very much greater. Of the two elements, carbon and hydrogen, the oxidation of which produces animal heat, the heat-value of the hydrogen is by far the greater.

VI. It is probable that there is always a certain amount of oxidation of hydrogen in the body, and that this is necessary to maintain the animal temperature; and it is almost certain that this occurs during prolonged abstinence from food and when the production of heat is much increased by violent and protracted muscular exercise. It may be, also, that there is an active and unusual oxidation of hydrogen as well as of carbon in fevers.

XXIII

FEVER; ITS CAUSE, MECHANISM AND RATIONAL TREATMENT—AN ADDRESS DELIVERED IN GENERAL SESSION AT THE NINTH INTERNATIONAL MEDICAL CONGRESS, SEPTEMBER 6, 1887

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In the classical monograph on inanition by Chossat, published in 1843, is the following sentence: Inanition is "a cause of death which marches in the front and in silence in every disease in which alimentation is not in a normal condition."

A few years later Graves, of Dublin, insisting on the importance of alimentation in the management of continued fever, said that if he had met with more success than others in the treatment of the disease, it was owing in a great degree to the counsel of a country physician of great shrewdness, who advised him never to let his patients die of starvation.

Nearly half a century has elapsed since Chossat, comparing the results of an extended series of experiments on the lower animals with pathological phenomena in the human subject, recognized inanition as a cause of death in diseases which were then treated by depletory and so-called antiphlogistic measures, and since the "shrewd country physician" advised Dr. Graves never to let his patients die of starvation. Within this half-century, the ideas embodied in the two quotations I have made have taken a permanent place among the accepted principles of the science of medicine. The researches of the physiologist enabled him to recognize the spectre of inanition, marching "in the front and in silence" with disease, and the great clinical observer "fed fevers"; the natural his-

tory of many diseases, undisturbed by active therapeutical measures, has been studied, and the self-limited character of a large number of these diseases has been established; and now, in the treatment of certain cases, abortive measures having been found ineffectual, the resisting and recuperative powers of patients are sustained.

An important result of the studies of physiologists with reference to animal heat, and of pathologists with reference especially to the essential fevers, is that, important organs being protected against serious complications and accidents and the nutrition of the body being measurably supported, a fever may run its course, leaving the patient in a physical condition in which speedy and complete convalescence is almost certain. The life of an acute disease usually is short; and a self-limited disease, such as typhoid fever, is a morbid force which calls for resistance on the part of the system for but a certain time. In cases of acute disease, as a rule there is an inherent tendency to recovery. A disease which involves in its course a rapid and abnormal consumption of matter within the body can rationally be met by the introduction and the assimilation, if possible, of nutritive material to save or repair the destruction of tissue. That there is abnormal destruction of tissue in fevers is rendered certain by the progressive loss in body-weight and the marked increase in the elimination of carbonic acid and nitrogenous excrementitious matters; and it is the province of the physician to keep this loss within the lowest limits and to repair it as speedily and as effectually as possible.

The principal object of this address will be to show how the metamorphosis of matter involved in the normal production of animal heat is accomplished, how the abnormal production of heat in fever, involving, as it does, abnormal activity in the metamorphosis of tissue, may be restricted, and how abnormal destruction of tissue may be limited and repaired.

It is well known to physiologists that the production of animal heat is one of the phenomena attendant upon the general processes of nutrition. It is also well known that the process with which the production of heat is most intimately connected is oxidation of certain matters which are either contained in food or form a part of the tissues

of the body. This fact, a knowledge of which dates from the researches of Lavoisier in the last part of the last century, has now become firmly established; and the relations between the consumption of oxygen (with the production of certain excrementitious matters) and the generation of heat within the body have, in late years, been the subject of much physiological experimentation. Attempts have been made by Senator and others, to measure directly the quantity of heat produced in the body, with the result of showing that, in mammals, there are produced about four heat-units per hour, per pound weight of the body.* According to this estimate, a man weighing one hundred and forty pounds would produce thirteen thousand four hundred and forty heat-units in twenty-four hours.

While the direct method of estimating the heat produced by the body has some elements of uncertainty, it has the advantage, at least, of being similar to the method by which the heat-value of food has been ascertained. On the other hand, the indirect method, employed by some observers, is said by Dr. Foster to be "as trustworthy as any." This method consists in "simply subtracting the normal daily mechanical expenditure from the normal daily income. Thus, one hundred and fifty thousand kilogramme-metres subtracted from one million kilogramme-metres, gives eight hundred and fifty thousand kilogramme-metres as the daily expenditure in the form of heat." † In this method the only reasonably accurate element in the calculation is the "normal daily income," which is ascertained by estimating the heat-value of food in a normal diet. The calculation of the "normal daily mechanical expenditure," is very inaccurate. The force expended in the circulation and respi-

* The English heat-unit represents the heat required to raise the temperature of one pound of water one degree Fahrenheit. The Continental heat-unit represents the heat required to raise the temperature of one litre of water one degree centigrade. One heat-unit, Continental, equals about four (3.9628) heat-units, English. Four heat-units per pound per hour (English) would equal about one heat-unit (Continental) per pound per hour, or 2.2 heat-units (Continental) per kilogramme per hour. In what is to follow, I shall adopt the English standard for the heat-unit.

† Foster, "Text-book of Physiology," London, 1883, p. 459. A kilogramme-metre, or a kilogramme lifted a metre, is equal to 7.232 foot-pounds, or pounds lifted a foot.—Pavy, "Food and Dietetics," Philadelphia, 1874.

ration is estimated, the force in locomotion and in other muscular work is guessed at and all of these estimates of expenditure of energy are calculated in foot-pounds, or kilogramme-metres, which are afterward reduced to heat-units. Taking the estimate of the work of the heart alone; if Dr. Haughton's calculation of the quantity of blood discharged by each ventricular systole, which is three ounces, is accepted, a certain result is arrived at; and estimating, on equally good authority, the quantity discharged at between five and six ounces, the figures are nearly doubled, and the error is multiplied by about one hundred thousand beats of the heart in twenty-four hours. The estimates, also, of the force used in respiratory movements, locomotion, etc., are not more reliable.

The late Dr. John C. Draper, following the experiments by Senator and others on the inferior animals, made a series of observations on his own person, in which he showed that his body, which he found was equal in bulk to three cubic feet, was capable of raising the temperature of three cubic feet of water five degrees Fahrenheit in an hour. During the observation, the temperature under the tongue was reduced one degree.* Making the correction (which was not made by Dr. Draper) of one degree lost by the body and imparted to the water, I estimated that the body produces four heat-units per pound weight per hour,† which is nearly the result obtained by Senator; and that consequently a man weighing one hundred and forty pounds would produce thirteen thousand four hundred and forty heat-units in twenty-four hours, in a condition of absolute repose. This quantity would, of course, be increased by muscular exercise.

In a series of experiments made upon my own person for twenty-four hours, under a liberal diet, I calculated the heat-value of the food ingested as equal to fourteen thousand nine hundred and seventy-nine and fifteen-hundredths

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* Draper, "The Heat produced by the Body," and the "Effects of Exposure to Cold" ("American Journal of Science and Arts," New Haven, December, 1872). Dr. Draper's experiments were made under conditions which possibly involved serious inaccuracies; and they are useful and interesting chiefly from the correspondence of the results with those obtained by Senator and others, in which corrections were carefully made.

† See foot-note, Article XXII., p. 71, and Article XXIV., "Remarks on Fever."

heat-units. At that time (1878), I weighed one hundred and eighty-six and one-half pounds, and according to my estimate I produced seventeen thousand eight hundred and eighty heat-units in twenty-four hours. There was no difference in the body-weight at the beginning and at the end of the observation. This observation showed that nearly one-sixth of the heat estimated as actually produced by the body was not accounted for by the heat-value of the food taken. There can be little question in regard to the accuracy of the accepted methods for estimating the heat-value of articles of food; and it follows logically that there must either be a grave error in the estimate of the heat produced by the body, or that there are certain processes going on within the body, not taken into account by physiologists, which involve a considerable production of animal heat. It is to be remembered, also, that I made no allowance for the conversion of a certain proportion of the heat produced in the body into force expended in circulation, respiration, locomotion, etc.

Indirect observations have shown that out of the daily quantity of hydrogen introduced in organic combinations in the food, a large proportion (about eighty-five per cent.) can not be accounted for by the organic constituents of the excretions; and it has also been shown that there generally is an excess of water discharged from the body over that introduced with the food and drink. In another experiment made on my own person, in 1878, I fasted for thirty-three hours, beginning my observations on the discharge of water nine hours after the beginning of the fast, in order to allow the digestion of the last meal to be completed. In twenty-four hours the discharge exceeded the introduction of water by forty-six ounces. I calculated the quantity of water discharged, by deducting from the total loss of body-weight the loss of solid maters in the urine and the estimated loss of carbon by the lungs. The quantity remaining represented the loss of water in excess of the water introduced. The quantity of water introduced was twenty ounces. No feces were passed during this observation.

In another observation the total discharge of water for a period of five days was estimated by the following method:

The weight of the ingesta for the five days was added to the body-weight at the beginning of the observation. From this were deducted the weight of the urine and feces for the five days, the estimated weight of carbon eliminated and the body-weight at the end of the observation. The result represented the total discharge of water by the lungs and skin, which, added to the water of the urine and feces, gave the total discharge of water. From this was subtracted the water introduced in food and drink. The total excess of water discharged for the five days was sixty-two and seventy-eight-hundredths ounces. The subject of this experiment weighed one hundred and nineteen and two-tenths pounds at the beginning of the observation. At the end of the five days, having walked three hundred and seventeen and one-half miles, he weighed one hundred and fifteen and seventy-five-hundredths pounds.

The observations thus briefly described seem to show that, under certain circumstances at least, water is actually formed in the body by the union of oxygen with hydrogen. In the observation made fasting for twenty-four hours, the quantity thus formed was very large. If it can be assumed that water is formed in this way, the heat-value of hydrogen being very great, there is little difficulty in accounting for the heat which has been estimated by direct observation to be produced in the body, as well as for a considerable surplus of heat expended in the form of muscular work. The theory, however, that the oxidation of hydrogen in the body is an important factor in the production of animal heat leads to somewhat novel reflections in regard to the physiological relations of water to the general processes of nutrition.

Water regarded as a Product of Excretion.—There are two substances that result from the physiological wear of the tissues, which may be taken as typical products of excretion. One of these, carbonic acid, is non-nitrogenous, and the other, urea, is nitrogenous. Both of these are produced in the tissues and are carried by the blood to eliminating organs. The excretion of both is influenced by the activity of molecular changes in the body. It is with these matters that I shall compare the water which is in all probability formed in the body and

discharged, under certain circumstances at least, in excess of the water of food and drink.

An excrementitious substance is one discharged from the body and produced by physiological wear, chiefly in the form of oxidation, of the organism. It is probable that the organism, under normal conditions as regards alimentation, use of parts, etc., produces a quantity of excrementitious matter which is fixed within certain physiological limits. When the alimentation is excessive, a certain proportion of nutritive matter is represented in an increased discharge of excretions. This is marked as regards both carbonic acid and urea, particularly in the increased discharge of urea under an alimentation containing an excess of nitrogenous alimentary matters. Starch, sugar, fats and proteids are not discharged from the body in health, but are eliminated in the form of carbonic acid, urea, urates, etc., and water. Muscular work largely increases the discharge of carbonic acid, in a less degree the discharge of urea, and it notably increases the discharge of water.* Muscular work also increases the production of animal heat; but the temperature of the body is regulated within normal limits by evaporation from the general surface. When an excess of food is taken habitually and for a long time, there generally results an abnormal accumulation of fat, it being impossible for the elimination of carbonic acid to keep pace with the introduction and assimilation of food, unless there should be a large expenditure of heat and force in muscular work. The excess of nitrogenous food is disposed of largely in the form of urea; but it is probable that a certain part of this excess is converted into fat, and the muscular substance can not be increased in bulk except by exercise, and then only within certain restricted limits.

As compared with carbonic acid and urea, the water produced in the body seems, to a great extent, to be subject to the same laws. It is a product of oxidation within the organism; its production may be influenced by

* Pettenkofer and Voit, " Journal of Anatomy and Physiology," Cambridge and London, 1868, vol. ii., p. 181. " The elimination of water is very much increased by work, and the increase continues during the ensuing hours of sleep." This was one of the conclusions arrived at from experiments upon a man, twenty-eight years of age, kept for twenty-four hours in a large " respiration apparatus."

alimentation, independently of the quantity of water introduced, and by muscular work; it is discharged through organs recognized as organs of elimination, such as the lungs, skin and kidneys; but its chief point of similarity with the matters generally recognized as excrementitious is in its mode of production.

It has been thought that excrementitious matters, if their elimination is interrupted, are of necessity poisonous when retained in the system. This certainly is not true of water; but the opinion upon this point, in regard to matters commonly regarded as excrementitious, is now open to serious question. It is probable that carbonic acid is not in itself poisonous, and that its retention in the blood produces death by interfering with the absorption of oxygen. There are few conditions under which an animal can be placed, in which carbonic acid can be made to accumulate in great quantity in the blood without interfering with the supply of oxygen; but in the well-known experiments of Regnault and Reiset, dogs and rabbits were exposed for many hours to an atmosphere containing twenty-three per cent. of carbonic acid artificially introduced, with between thirty and forty per cent. of oxygen, without any ill effects. It is now thought by some pathologists that the so-called uremic convulsions are not due to the poisonous effects of the retention of urea in the blood, although this is still an open question.

If it is assumed that water is produced *de novo* in the economy, in its method of production it closely resembles carbonic acid; but it differs from carbonic acid in having certain uses so important as to lead to its frequent introduction with the food and drink. Its chief use, however, as regards nutrition, is as a solvent; but in this it is aided by carbonic acid, the presence of which, especially in the urine, increases the solvent properties of the liquids of the organism. It is evident, also, that water, as a constituent part of the tissues, tends to preserve their proper consistence.

The water of food and drink has important indirect uses connected with nutrition, both as a solvent of nutritive and excrementitious matters and as a constituent part of the tissues; but the water produced within the body by the union of oxygen with hydrogen behaves, in the manner

of its production and elimination, like excrementitious matters.

If this view is accepted, it is evident that the two excrementitious matters with which the production of animal heat is most closely connected are water and carbonic acid. Under ordinary conditions of alimentation carbonic acid probably has the greater relative importance; but in starvation, while the excretion of carbonic acid is diminished, the formation of water, as shown in my starvation experiment, is probably very largely increased. It is evident that the production of carbonic acid is a much more important factor in the generation of animal heat than is the formation of urea. In the experiment referred to, I calculated the heat-value of the urinary nitrogen as equal to one thousand six hundred and seventy-seven and seventy-hundredths heat-units, and the heat-value of the carbon eliminated as equal to ten thousand seven hundred and fifty-nine and nine-hundredths heat-units. The deficiency, as regards the heat actually produced, must have been represented by the excess of water discharged, which was forty-six ounces, the hydrogen of which has a heat-value equal to nineteen thousand seven hundred and fifty-one and seventy-five-hundredths heat-units.* Persons exposed to intense cold, as in the Arctic regions, are known to require large quantities of food rich in fatty matters; † and the excretion of carbonic acid is probably very greatly increased, although direct observations on this point are wanting.

The foregoing remarks on the physiology of animal heat have been preliminary to a discussion of fever; and the influence of the nervous system upon calorification, which is so important in disease, will be considered only in its pathological relations.

The Mechanism of Fever.—The phenomena and mechanism of fever in all its varieties constitute a subject much too large for full discussion within the proper limits of this address. It has been rendered probable by recent

* The temperature under the tongue at the beginning of the twenty-four hours of the observation was 99° Fahrenheit. At the end of the twenty-four hours it was 97¾.

† The late Dr. Hayes stated that on one occasion he saw an Esquimau consume ten pounds of walrus flesh and blubber at a single meal.—"American Journal of the Medical Sciences," Philadelphia, July, 1859.

bacteriological studies that all of the essential fevers are due primarily to the influence of microörganisms, those producing typhoid fever, especially, having been isolated, cultivated and accurately described. Fevers symptomatic of local inflammations will form no part of the question now under consideration; and I do not propose to take up the question of pyrexia due to exposure to external heat, as in insolation. The condition which I shall consider as the type of fever is the pyrexia in typhoid fever, due to a microörganism and having a duration restricted within certain limits which do not present very wide variations. Typhoid fever is strictly an essential fever, producing, like other fevers, certain parenchymatous degenerations and certain secondary effects upon the nervous system; but it is only the nature, mechanism and rational treatment of the fever itself which I propose to discuss.

The cause of the pyrexia in typhoid fever is twofold. The more important factor is an exaggeration of those chemical changes taking place in the organism which generate the animal heat within normal limits. A less important factor is a disturbance of the processes of equalization of the heat of the body, mainly by the action of the skin. That an exaggeration of heat-producing processes within the body is an important element in the production of fever, is rendered certain by the excessive consumption of oxygen and discharge of carbonic acid and urea. In health the discharge of carbonic acid and urea is compensated by the introduction of food; which also has a certain influence upon the quantities of these substances eliminated. In health there are important influences, also, which depend on muscular work and activity. In an essential fever the heat-producing processes seem to be for the time removed from normal regulating influences. Even when no food is taken, the fever continues and the excessive discharge of carbonic acid and urea progresses. The regulating action of the skin is often impaired or absent. In a fever in which no attempt is made to support the system by alimentation, the phenomena of inanition are added to those of the pyrexia. Simple inanition in a healthy subject is marked by a diminution in the excretion of carbonic acid and urea, with a lowering of the animal temperature, and there is usually but little

muscular work. In an essential fever, it seems as if the body were at work, producing an excessive discharge of excretions, without adequate compensation by sufficient alimentation. Assuming a failure of measures employed to abort the disease, the excessive waste of tissue pursues its course until the morbid processes are arrested by self-limitation, or until the patient dies, either from secondary effects, referable to the persistence of very high temperature, or from simple asthenia. In cases of death from uncomplicated typhoid fever, there usually is very great emaciation.

The waste of the organism usually is most marked as regards the adipose tissue, the destruction of which probably is represented in greatest part by the excessive discharge of carbonic acid. The muscles, too, undergo degeneration, which is at first of the kind called parenchymatous. The destruction of the muscular tissue probably is represented in greatest part by the excessive discharge of urea.

If we can logically view water formed in the body in the light of an excrementitious product, the formation of which in health is closely connected with the process of calorification, the changes noted in most of the cases of typhoid fever, as regards the production and discharge of water, become very important. In nearly all essential fevers there is thirst, but the discharge of water by the skin and kidneys is notably diminished, especially the discharge by the skin, which often is dry and hot.

In health the formation of water, with its inevitable production of heat, seems to carry with it the conditions for equalization of the animal temperature by cutaneous transpiration. In simple inanition the tissues of the body are economized, as it were, by the excessive formation of water and the increased prominence of this process in calorification. In health when there is excessive muscular exertion there is an increased discharge of water, as was noted by Pettenkofer and Voit. In fever, however, the fats and solid tissues undergo destruction and certain degenerations. The formation of water seems to be diminished, and certainly there is a diminished discharge of water from the body attending the increase in the discharge of carbonic acid and urea. Whatever may be the

essential cause of the pyrexia, the consumption of matter in the production of the excessive heat is chiefly of fat and muscular tissue; presenting a striking contrast to the process of calorification in simple inanition and in violent muscular exercise, which latter would raise the temperature of the body much higher were it not for the increased formation of water and the cutaneous transpiration. It would seem that in health, when there occurs any unusual demand for heat to be used in muscular work, the production of water as well as of carbonic acid is increased; while in fever, the pyrexia is fed, so to speak, by the fatty and solid tissues of the body alone. In health muscular work confined within normal limits stimulates nutritive activity and the assimilation of food. In fevers the activity is mainly degenerative and the assimilative processes are seriously impaired.

These considerations lead naturally to some modification of accepted views in regard to the theories of fever and render ideas on these questions more positive and definite than heretofore. I shall express these ideas in the form of propositions, some of which are to a certain extent novel:

I. It is probable that the original cause of most if not of all the essential fevers is a microörganism, different in character in different forms of fever.

This proposition is based on bacteriological researches of recent date, especially in regard to typhoid fever.

II. Defining fever as an abnormal elevation in the general temperature of the body, the pyrexia is due to the following modifications in the normal heat-producing processes:

(a) Oxidation of certain constituents of the tissues, probably due to products of microörganisms in the blood, is exaggerated independently of increased muscular work and without being compensated by a corresponding increase in the appropriation of nutritive matters. This increased waste of tissue is represented by an excess of carbonic acid and urea excreted.

(b) The part which the formation of water within the body plays in the production of heat is either suppressed or is greatly diminished in prominence, as well as the equalizing action of cutaneous transpiration.

This proposition is based on clinical facts which show an increased excretion of carbonic acid and urea and a diminished excretion of water in fevers, and on experiments which show that muscular work, while it increases heat-production, increases the production of water.

III. Fever produces abnormal consumption of fat, with parenchymatous degenerations, for the following reasons:

(a) The fat is consumed because it feeds the pyrexia more readily than do the other tissues of the body; and its consumption is the most important source of carbonic acid.

(b) Parenchymatous degenerations of muscular tissue and of the solid organs occur chiefly because the abnormal transformations of these parts, which result in an excess of urea and which probably contribute also to the excess of carbonic acid, are not compensated by the appropriation of nutritive matters.

(c) It is well known that patients with unusual adipose or muscular development are likely to present a more intense pyrexia in fevers than are those whose adipose and muscular development is smaller.

Finally: An essential fever is an excessive production of heat in the body, induced by a special morbific agent or agents, and due to excessive oxidation, with more or less destruction of the tissues of the body, and usually either a suppression or a considerable diminution in the production of water.

Suppression or great diminution of cutaneous transpiration in the essential fevers, while it contributes in a measure to the rise in temperature, is not itself a cause of fever.

I do not propose to discuss at length the influence of the nervous system on the normal production of heat or on fevers. It is well known that the nervous system is capable of modifying the local circulations and of producing local changes in temperature. Some physiologists have endeavored to locate a heat-centre, as well as a vaso-motor centre, and some varieties of fever are regarded as due to morbid action of nerve-centres, either direct or reflex. A consideration of these questions, except in so far as the nervous system is secondarily affected in fevers, would extend this address beyond its proper limits. I

shall, however, allude to certain conditions of the nervous system in fevers in connection with what I shall have to say on the subject of treatment.

Rational Treatment of Fever.—Symptoms referable to the nervous system are nearly always more or less prominent in essential fevers of a grave character. In the great majority of cases at least, the disturbances of the nervous system are secondary and are due to the pyrexia, being intense generally in proportion to the intensity of the fever itself. While the special morbific cause of typhoid fever is, of course, the cause of the delirium, coma vigil, hebetude, etc., which are observed in certain cases, it is rational to suppose that it acts as a secondary cause of these phenomena, by virtue of changes induced directly by the prolonged elevation of body-temperature; and the same may be said of the pulse, which is high usually in proportion to the intensity of the pyrexia. Certain it is, that a mere reduction of the temperature, by means which can not be presumed to affect the special cause of the disease, is nearly always attended with an amelioration of the nervous symptoms and a reduction in the rate of the pulse.

The parenchymatous degenerations and the alterations in the structure of the muscles and of the secreting cells of glands are unquestionably due to modifications in nutrition produced by the action of microörganisms; and it is well known that in typhoid fever and in pneumonic fever these microörganisms are deposited in special parts, as the intestinal glands and the lungs. It is certainly a rational object of treatment to confine these degenerations within the narrowest possible limits.

While it is not possible exactly to limit different measures of treatment to particular phenomena, there are certain therapeutical indications specially called for by morbid processes which relate to different systems and organs of the body. These measures may be classified as follows:

I. Reduction of the general temperature by the external application of cold.

II. Reduction of temperature by the internal administration of antipyretics.

III. Promotion of general nutrition by alimentation.

IV. Measures to supply to the system matters that can be consumed in the excessive production of heat, thereby retarding destruction of tissue.

The application of cold to the surface by means of cold baths, sponging, etc., is now almost universal in the treatment of the essential fevers. While the value of this therapeutical measure is undoubted, and while its employment of late years has unquestionably diminished the fatality and abridged the duration of typhoid fever, writers are not agreed on an exact explanation of its mode of action.

If the proposition that fever is due to the excessive production of heat is to be accepted as true, the explanation of the beneficial effects of refrigeration of the surface in fevers seems to me to be very simple and entirely satisfactory.

In health, when the body is subjective to excessive cold the normal temperature is maintained, not only by retarding the radiation of heat from the surface by appropriate clothing but by an actual increase in the production of heat. External cold increases the consumption of oxygen and the production of carbonic acid. The increased production of heat is promoted by muscular exercise, and the material necessarily consumed is supplied by what, under ordinary conditions, would be an excessive assimilation of food, particularly of fatty matters, which have a high heat-value. The large consumption of fats in excessively cold climates is an evidence of this fact.

In fevers there is an excessive production of heat, which raises the temperature of the body, partly for the reason that the equalizing action of cutaneous transpiration usually is impaired. If part of this excessive heat is removed by the application of cold to the surface, the temperature of the body is necessarily reduced; and it remains only for clinical observation to determine whether or not this reduction of temperature is beneficial. Its beneficial effects, however, are unquestionable.

Physiological and pathological conditions are thus brought into striking contrast; and the pathological phenomena are readily explained in accordance with physiological principles.

In the healthy body exposed to excessive cold, the condition of cold is met by a physiological increase in the

processes of calorification and by protection of the surface against loss of heat.

In the organism affected with fever, there is, as a fixed condition, an exaggeration of the processes of calorification. This is to be met by artificial external conditions in which the excess of heat is abstracted from the body.

The clinical thermometer, the general condition and the sensations of patients afford a sure guide in regard to the extent to which external cold should be applied in any individual case; and the application of cold to the surface is certainly a rational measure of treatment in fever.

The amelioration of the nervous symptoms and the reduction of the pulse-rate, which usually follow reduction of temperature by external refrigeration, are arguments in favor of the view that these symptoms are due mainly to the pyrexia itself and not to the direct action of the specific morbific agent which produces the disease.

Analogous effects are produced, although in a different way, by internal antipyretic remedies, of which antipyrin and antifebrin are now extensively used in this country in the treatment of fevers. The mode of action of antipyrin is not well understood, but its action in reducing temperature is universally admitted. Extended and complete observations, however, on the influence of this drug upon the elimination of excrementitious matters are as yet wanting.

Alimentation in Fever.—It is in accordance with accepted views concerning the physiological production of animal heat and its exaggeration in pyrexia, to supply food in fever in such quantity as can be digested and assimilated, with a twofold object. The only objection to alimentation within the limits of assimilation would be clinical experience showing an increase in pyrexia or in other morbid symptoms; but clinical experience shows, on the contrary, that innutrition adds to the intensity of all the morbid phenomena characteristic of the disease. There is no disease in which the spectre of inanition is more prominently "a cause of death which marches in the front and in silence" than in typhoid fever. An unusual physiological demand for heat is met by increased alimentation. The pathological increase in the produc-

tion of heat in fever is attended eventually by destruction of tissue and results in degenerations.

The most prominent and important object of alimentation in fever is to supply or retard waste of tissue and degenerations. In so far as this end is attained, the ravages of fever are restrained. The disease having pursued its course, in proportion as its effects on nutrition are restrained, the system is better prepared for rapid and complete convalescence.

A second object in alimentation, less prominent and important merely because more difficult and uncertain in practice, is to supply material for consumption, and thus far save destruction and degeneration of tissue.

The extent to which alimentation, therefore, is to be carried is limited only by the powers of the digestive system. Unfortunately, however, the degenerations and disturbances of function which occur in fever are prominent in the digestive organs. It is seldom if ever possible for a patient to assimilate food in sufficient quantity to repair the waste of tissue; but it is rational to endeavor to secure as much assimilation as is practicable. The difficulties in the way of efficient alimentation are due to degenerations of the glands of the stomach, to which are frequently added, degenerations of the secreting cells of the salivary glands and pancreas. The practical skill of the physician is taxed to the utmost, in individual cases, to overcome these difficulties; but the judicious administration of milk, eggs, meat-broths, meat-essences, etc., is always productive of good results. A part of the nutritive constituents of these articles goes to repair the waste of tissue, and it is logical to conclude that a part supplies matter consumed in the production of heat. It is also rational to assume that, the repair of tissue being carried to the greatest possible extent, the carbohydrates and fats must be useful in supplying material for those processes which are represented by the excessive elimination of carbonic acid. In no case of fever is it possible actually to accumulate fat in the system during the progress of the disease; and carbohydrates and fats introduced must contribute to the formation of heat and thus restrict parenchymatous degenerations.

The disturbances which follow an alimentation carried

to a degree beyond the powers of the digestive organs afford a reliable guide as regards the extent to which food should be introduced in fevers; and in my judgment, too little attention and care have been given to the administration of articles of food which have a high heat-value, such as fatty matters.

As a digression, bearing, however, on the question of the value of fats in conditions involving excessive production of heat, I may allude to their use in pulmonary phthisis.

I assume it to be settled that phthisis is produced by a special microörganism. One of the most prominent general phenomena of phthisis is a constant elevation in the body-temperature. When the disease is progressive there is an increase in the heat of the body. When the disease is non-progressive, as indicated by physical signs, arrest of loss and perhaps increase of weight and absence of bacilli from the sputum, the temperature of the body becomes nearly or quite normal. The pyrexia in phthisis ordinarily is not sufficiently intense to induce of itself serious disorders of digestion or much general disturbance; and the difficulties in the way of the assimilation of fats usually are not great. Leaving out of consideration for the present the effects of alcohol, there is no measure in the treatment of phthisis of greater recognized therapeutical value than the administration of fats.

The Use of Alcohol in Fever.—Alcohol is a substance, the toxic effects of which, taken in excess, are quickly and distinctly manifested; and there are few agents more prompt and decided in their influence in cases of disease. Clinically the effects of alcohol in diseases in which there is a tendency to death by asthenia are so marked that it is often used indiscriminately and injudiciously. In the treatment of fever the benefit which follows the use of alcohol in certain cases led at one time to its use under all circumstances; and its indiscriminate administration, on the other hand, has produced from time to time a reaction of opinion leading to its suppression in cases in which it would be of great service. Many of the moral arguments against the use of alcohol in disease are entirely illogical and could with equal lack of propriety be applied to a number of important articles

of the materia medica. Alcohol often is a potent agent in the treatment of fever; and the clinical guides which should direct its administration are easily recognizable.

In no case of disease, except perhaps in certain instances of poisoning by animal venoms, should alcohol be administered to a point where any degree of alcoholic intoxication is apparent.

Alcoholic intoxication is due to certain peculiar effects of alcohol on the nerve-centres; and in order to produce these effects the alcohol must circulate in the blood. As these effects pass off, the alcohol is either oxidized or is eliminated by the skin, lungs and kidneys. Under normal conditions of nutrition the effects of alcohol are so rapid and transitory, and are followed by such decided reaction, that it contributes little or nothing toward a prolonged resistance to cold. Experience has shown that it can not take the place of an abundant and a highly fatty alimentation in excessive cold, as in the Arctic regions; and under these conditions its constant use has been found to be positively injurious. The same remark is in a measure applicable to all conditions of normal nutrition. In a continued fever, however, the conditions are radically changed. In accordance with the views which I have presented, the excessive production of heat in fever is a fixed condition, continuing for a certain period limited by the duration of the disease. The phenomena referable to the pulse, to the nervous system, etc., are secondary to the pyrexia. The parenchymatous degenerations are the more remote changes of tissue which follow and result from transformations involved in the long-continued excessive production of heat. If these views are accepted as correct, any readily oxidizable substance artificially introduced will, if it is oxidized, mitigate the secondary effects of the fever upon the pulse and nervous system and retard degenerations, provided always that it does not increase the intensity of the pyrexia. Experience is not wanting to show that these results follow the judicious administration of alcohol in fever.

Inanition is also a constant element in a fever long continued. In health the formation of water in considerable quantity in the production of heat occurs in the first part of a period of deprivation of food; and this saves to

a certain extent destruction of the solid tissues. One of the most marked and constant conditions in fever is a disturbance of the heat-producing processes, in which the solid tissues are consumed and the production of water is greatly diminished. It is a rational measure of treatment to endeavor to restore the normal equilibrium between the consumption of the so-called solids and the formation of water as factors in the production of heat. If it were possible to introduce farinaceous and fatty articles of food in sufficient quantity in fever, it might not be necessary or desirable to use alcohol; but the condition of the digestive organs is such that these articles are slowly and imperfectly prepared for absorption. Alcohol, however, requires no preparation by digestion. It is promptly taken up by the blood and is oxidized much more readily in fever than in health.

It is well known that saccharine and starchy articles of food, as well as the liver-sugar, rapidly disappear, and that starch is converted into sugar in digestion. In a paper by Dr. William Hutson Ford, a number of experiments are published, showing the presence of alcohol in small quantity in the normal blood, resulting, according to Dr. Ford, from the decomposition of sugar. In this paper Dr. Ford makes the following statement:

"The destination of alcohol, whose presence in the economy I have thus demonstrated, must be to a hemal oxidation or 'combustion,' as a main source of animal heat. This combustion is maintained, not only by glucose derived from amylaceous food, but likewise from the proximate products of change in the nitrogenous tissues." *

The thermal phenomena observed in diabetes mellitus are of interest in connection with the theory that carbohydrates are converted into alcohol, the oxidation of which is an important factor in the production of animal heat. In nearly all cases of diabetes there is a constant and persistent depression of the animal temperature. The chief pathological condition in this disease is manifested by a discharge from the body, in the form of sugar, of

* Ford, "The Normal Presence of Alcohol in the Blood."—"New York Medical Journal," June, 1872, p. 594.

the carbohydrates of the food; and as a consequence these substances are not used in the production of heat. The result is a depression in the temperature, with a loss of weight which is often very rapid,* due to a consumption of the fatty and nitrogenous parts of the tissues and to certain parenchymatous degenerations, which are observed particularly in the cells of the kidneys. It may seem paradoxical to say that diabetes is attended with a fever in which the temperature of the body is depressed. In progressive phthisis there is actually a fever marked by elevation of temperature. In diabetes the fatty and nitrogenous parts are consumed to an abnormal extent, as in fever; but the heat-producing action of the carbohydrates being suppressed, even this excessive consumption of fats and proteids is inadequate to maintain the normal standard of the body-temperature. The theory that the carbohydrates are converted into alcohol which is oxidized in the body is entirely in accordance with my view that the production of water is an important factor in the production of animal heat. If alcohol is oxidized in the body, as it is in certain quantity, the production of water is inevitable. The heat-value of the hydrogen in alcohol being very great, and if (the carbohydrates being discharged in the form of sugar in diabetes) the normal heat of the body is not maintained, the final oxidation of these carbohydrates, with the consequent production of water, is an important factor in the production of animal heat. The excessive quantity of water discharged in diabetes probably comes in great part directly from the blood and the watery parts of the tissues, which accounts for the intense thirst observed in grave cases of this disease.

In the administration of alcohol in the treatment of fever, are we not using the carbohydrates in a form in

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* The history of a diabetic patient who consulted me in November, 1885, showed a loss of weight amounting in three years to one hundred and forty-five pounds. The patient was six feet three inches tall, and weighed, before the disease was recognized, three hundred and seventy-five pounds. Under treatment for five days, the quantity of urine was reduced from one hundred to forty fluidounces, and the proportion of sugar, from twenty-seven to two grains per ounce. The patient then passed from under my direct observation, and the discharge of sugar was increased by indiscretions in diet. Ten months after, the patient wrote me that he "felt perfectly well," and had gained forty pounds in weight.

which they may be immediately oxidized and do not require preparation by digestion? Material to meet the excessive waste involved in the pyrexia may thus be easily supplied, in much the same way as peptonized proteids are administered to meet the excessive waste of the nitrogenous parts of the tissues when the digestive powers are impaired.

It is a matter of clinical observation that there is unusual tolerance of alcohol in fevers and in pulmonary phthisis. This tolerance of an agent which is probably never useful in perfect health is strong evidence of a demand on the part of the system for the class of alimentary matters, the carbohydrates which alcohol represents; and it affords an absolute guide as regards the quantity that should be employed. The quantity that will be useful in individual cases may be small or it may be great. In certain exceptional cases, one or two ounces of spirit may be administered hourly for a day or two, with the best results; and this quantity may be taken without the slightest manifestation of alcoholic intoxication. With an alarmingly high temperature, a rapid and feeble pulse and grave ataxic symptoms indicating impending death, alcohol may be given largely, but never to the extent of producing its characteristic toxic effects.

In fever only such quantity of alcohol as is readily oxidized is useful; and any excess, which will certainly produce some degree of alcoholic intoxication and which must be eliminated as alcohol, will be productive of harm. In ordinary cases of continued fever it is seldom necessary or desirable to give more than eight or ten ounces of spirit daily.

I do not wish to be understood as advocating an indiscriminate use of alcohol in all cases of fever. Alcohol is indicated by an excessively high temperature, with the ataxic and other symptoms to which I have referred. In ordinary cases of typhoid fever, particularly in the early stages, it should be administered sparingly, cautiously and tentatively. Its quantity should be reduced or it should be omitted at the first indication of alcoholic intoxication. Nevertheless, alcohol, judiciously administered, so that all that is introduced is promptly and completely oxidized, as it contributes material for consumption in the produc-

tion of excessive heat, exactly in that degree does it retard destruction and degeneration of tissue; and it may be employed to supplement the use of matters that are regarded as nutritive.

I am deeply sensible of the great honor of an invitation to address this Congress. This invitation I felt bound to accept, although with a full appreciation of the responsibility which it involved and with much doubt and timidity in regard to my ability to do even a small measure of justice to the occasion. I have selected a topic of great present interest, which has been the subject of much fruitful study within the last few years. In discussing this subject, I have endeavored to apply the physiological methods of study that have lately contributed so largely to the advancement of pathology and therapeutics. I have been led by my reflections upon animal heat and fevers to present certain views which I venture, in conclusion, to summarize in the following propositions:

I. Fevers, especially those belonging to the class of acute diseases, are self-limited in their duration and are due each one to a special cause, a microörganism, the operation of which ceases after the lapse of a certain time.

II. Physicians are as yet unable to destroy directly the morbific organisms which give rise to continued fevers and must be content, for the present, to moderate their action and to sustain the powers of resistance of patients.

III. The production of animal heat involves oxidation of parts of the organism or of articles of food, represented in the formation and discharge of nitrogenous excrementitious matters, carbonic acid and water.

IV. As regards its relations to general nutrition and the production of animal heat, water formed in the body by a process of oxidation is to be counted as excrementitious.

V. Fever, as observed in the so-called essential fevers, may be defined as a condition of excessive production of heat, involving defective nutrition or inanition, an excessive production and discharge of nitrogenous excrementi-

tious matters and carbonic acid, with waste and degenerations of the tissues and more or less interference with the production and discharge of water.

VI. Aside from the influence of complications and accidents, the ataxic symptoms in fevers, the intensity and persistence of which endanger life, are secondary to the fever and usually are proportionate to the elevation of temperature. These symptoms are ameliorated by measures of treatment directed to a reduction of the general temperature of the body.

VII. The abstraction of heat by external cold and possibly the reduction of temperature by antipyretics administered internally, without affecting the special cause of the fever, improve the symptoms that are secondary to the pyrexia.

VIII. In health, during a period of inanition, the consumption of the tissues in the production of animal heat is in a measure saved by an increased production and excretion of water.

IX. In fever, the effects of inanition, manifested by destruction and degeneration of tissues, are intensified by a deficient formation and excretion of water.

X. Alimentation in fever, the object of which is to retard and repair the destruction and degeneration of tissues and organs, is difficult mainly on account of derangements of the digestive organs; and this difficulty is to be met by the administration of articles of food easily digested or of articles in which the processes of digestion have been begun or are partly accomplished.

XI. In the introduction of the carbohydrates, which are important factors in the production of animal heat, alcohol presents a product which is promptly oxidized and in which absorption can take place without preparation by digestion.

XII. In so far as it is oxidized in the body, alcohol furnishes matter which is consumed in the excessive production of heat in fever and saves destruction and degeneration of tissue.

XIII. The introduction of matters consumed in the production of heat in fever diminishes rather than increases the intensity of the pyrexia.

XIV. As the oxidation of alcohol necessarily involves

the formation of water and limits the destruction of tissue, its action in fever tends to restore the normal processes of heat-production, in which the formation of water plays an important part.

XV. The great objects in the treatment of fever itself are to limit and reduce the pyrexia by direct and indirect means; to limit and repair destruction and degeneration of tissues and organs by alimentation; to provide matters for consumption in the abnormal production of heat; and thus to place the system in the most favorable condition for recuperation after the disease shall have run its course.

XXIV

REMARKS ON FEVER; CLOSE OF DISCUSSION IN THE KINGS COUNTY MEDICAL ASSOCIATION ON THE ADDRESS ON FEVER BEFORE THE INTERNATIONAL MEDICAL CONGRESS HELD IN WASHINGTON IN 1887.

Published in "Gaillard's Medical Journal" for February, 1888.

I REGRET that I have not been able to adequately prepare myself to make some remarks upon the subject under consideration and to answer some of the criticisms that have been made on the paper that I had the honor to read before the International Congress; but I have hardly any excuse to offer except that I put it off, perhaps too long, being engaged in other work, and I found at the last moment time was lacking. Consequently I have to depend on the moment for what I shall have to say.

I am much pleased that this important subject is brought to the notice of the Association through a discussion of my paper; and I feel more than gratified and flattered at having been the means of bringing this subject before you. I have listened with great interest to the papers of the two gentlemen who have preceded me, looking upon the subject to which I have given a great deal of thought, as they do, with different eyes, approaching it in different ways and to a certain extent, with different habits of mind and thought. If I have made a mistake or mistakes in this paper, I am only too ready to acknowledge them and happy to be corrected in a way which is so agreeable as well as instructive.

I may state that my objects in studying fever were to carry out certain ideas that I had entertained on the subject of animal heat, which I find at this late date were

based on an error, not a large error, but still an error. This error, however, led me to what I believed to be the truth.

In thinking and working on the subject of animal heat, I tried to account for all the heat that was assumed to be actually produced in the body; and I adopted the estimates of Senator and of the late Dr. Draper, arrived at by direct observations, of four heat-units produced per pound weight of the body per hour. Since I wrote this paper I have changed my views; and I think that the direct method presents such difficulties in the way of proper correction and so many errors that seem at the moment insurmountable, that I have adopted the estimate, arrived at by the indirect method, which is two and a half heat-units per pound weight of the body per hour instead of four. Nevertheless, I do not think that the heat produced by the body, that used in warming the body, and that which is converted into force in the various movements, including circulation, respiration and muscular movements, can be accounted for without assuming that water is produced *de novo* in the organism. In studying this subject since I wrote the paper, I find more and more corroboration of the fact that water is produced in the body. I think that there can not now be a question, not only that water is produced in the body, but that water is produced in a very considerable quantity. It is easy to estimate the quantity of water taken in as drink and with the solid food; but there is great difficulty in estimating the quantity of water discharged. It is easy enough, however, to estimate the quantity discharged in the urine and feces; but as regards the skin and lungs, the difficulty is very considerable. In the observations that I made on a pedestrian and in the experiments made on my own person, I arrived at the latter by estimating the carbon discharged by the lungs, adding this to the weight of urine and feces and then calculating the loss of weight over and above the weight of the ingesta; but in this I was forced to estimate the water from the skin and lungs together.

In regard to that part of my definition and description of fever in which I state that it involves either a suppression or a great diminution in the production of water,

I do not pretend to say that this may not be modified, so far as my own views are concerned; and probably the general views in regard to this subject will be modified as knowledge advances and as the relations of water to animal heat become more and more clearly understood. There are no accurate observations with which I am acquainted showing the variations in the production of water in fever. Certain observations showing the effect of work upon the production of water have been made by Pettenkofer in his "respiration chamber," and they are accurate; but I do not know that a typhoid fever patient has ever been put into this chamber and his excretions measured. This would be very desirable, for there exists no accurate information regarding the details of the processes by which the tissues pass away in the emaciation and loss of body-weight which occurs in fever. A part of the loss is in the form of urea, in carbon united with oxygen to form carbon dioxide and in water; but of the details of these processes, there is no positive knowledge. Still, it seems to me that the difference between the increased production of water following bodily work of a severe and protracted character and the increased production of water in fever are very considerable. There is no question that when a much larger quantity of heat than is usual is produced by work there is a large increase in the production of water, as is shown by increased exhalation from the skin and lungs. It has been shown by Pettenkofer that this increase in the production of water is absolute and continues for about twelve hours after the exercise has ceased.

The picture that appears before my eyes, of a patient suffering from a fever that is self-limited, is one of great interest. Here is a person lying in his bed, doing no work, incapable for the time of doing any work, and yet there is something that is consuming his body and producing a great excess of heat, and his tissues are in a measure passing away. The tissues that remain are subjected to certain conditions, among the most important of which is a persistent elevation of temperature. Under these conditions the tissues are undergoing degenerations. Why that occurs, how microörganisms set up this process, I do not know.

I avoided the question of nervous action in considering the pathology of fever because I know very little about it and could not contribute anything of value on that subject. It is a subject which, with present knowledge, seemed, if not hopeless, at least very discouraging. But there is one important object which I had in view, and that related to the rational treatment of fever. I believe that there is a large number of physicians who do not wish to look to the autopsy-room only for the results in cases of disease; and I think there are points in disease more interesting than the post-mortem examination, certainly more important to the patient. I do not pretend to have brought forward anything new in regard to treatment. Fevers have been fed since Graves; fevers have been treated with water since Currie; fevers would long ago have been treated with antipyrin and antifebrin if these drugs had existed. Attempts have been made to reduce temperature with quinine, and fevers have been treated with alcohol very largely. These are well-established measures of treatment, in some minds, although all do not agree upon these points, particularly as regards antipyretics and alcohol. It has seemed to me that clinical experience, in regard to reduction of temperature, alimentation and the use of alcohol, pointed to but one thing. These measures of treatment in the main are good, unless contraindicated by some complication. If they are good, is it not possible to find a physiological reason for this? This is what I have attempted. As regards the reduction of temperature: in fever, as the fixed condition, the production of heat is largely in excess of that produced in health. A large quantity of heat may be produced normally; but then alimentation is proportionally large. In cold climates, for example, a large quantity of heat must be produced in order to keep the temperature of the body at the normal standard. In fever the heat is produced independently of external conditions, and to such an excess that the actual temperature of the body is considerably increased. It might well seem at the first glance to be absurd to cool a fever patient with ice, when one can not or does not attempt to limit the actual production of heat; yet this is done with good effect. The abstraction of enough heat from the body, however, by means which

do not produce unfavorable symptoms, to bring the temperature nearly to the normal standard and keep it below the point at which parenchymatous degenerations occur, is productive of good results. I had in Bellevue Hospital during the past summer and fall about twenty cases of typhoid fever. They were all treated on nearly a routine plan, which was simply this: keeping down the temperature by external cold and by internal antipyretics, feeding as much as possible and giving alcohol when necessary. This was the routine laid down for the treatment, and all recovered. In none was there any marked feature of the disease except great mildness; and so it was impossible to say whether the results were due to the character of the disease or to the treatment, except in one. There was one case in which the temperature was very obstinate and could not be reduced by antipyrin. The rule was to give antipyrin when the temperature rose to 103 (a dose of five grains) and to repeat it in six hours in case the temperature was not reduced. The temperature had been easily controlled by antipyrin for a certain number of days, but it rose at one time to nearly 107°. The patient was then put in the " wet pack "; that is, a blanket moistened with tepid water, and then sprinkled with water colder and colder until the temperature became reduced nearly to the normal standard. This procedure brought the temperature down, and for a few days it was manageable with antipyrin. Then there was another increase in temperature and I ordered the wet pack again. The patient beckoned to me and said, " I am too weak, I can not stand that again." Nevertheless, he was put in again with the same effect as before. The temperature was brought down the second time and then became perfectly manageable. This patient made an excellent convalescence. I do not know anything in the history of these cases that was so marked as the great craving for food experienced at the beginning of convalescence. It seems to me that the reduction of the temperature is a broad indication; and that the danger, in a prolonged high temperature, of degenerations and reactions upon the nervous system may be measurably avoided if the temperature can be reduced. Undoubtedly, in cases where there is a persistent high temperature, there are symptoms referable

to some influence on the nervous system, and it is hard to tell what the mechanism of this influence is.

As regards alimentation, it is a mere question of the quantity of food that can safely be introduced, within certain limits. When the body is losing weight under this destruction of tissue, consisting very largely in excretion of urea, with water and carbon dioxide, this waste must be supplied, or else when the disease runs its course, there can be no recovery.

There is one point that I particularly desire to discuss, and that relates to the administration of alcohol. The paper that I referred to in my address, by Dr. William Hutson Ford, printed nearly twenty years ago in the "New York Medical Journal," is simply a condensation of a paper embodying the details of a large number of experiments, which he sent to a number of medical journals in different parts of the country and was unable to have published. The abstract that I refer to was sent to the "New York Medical Journal." Dr. Lusk was at that time the editor, and he found this paper among others that had been thrown aside. The question now is simply: "Does alcohol exist in the normal blood?" No matter how small the quantity may be, this is a most important fact, upon which ideas of the mechanism of the digestion of the carbohydrates may be found to depend. Dr. Ford stated in a general way that the production of alcohol from the carbohydrates is concerned in the generation of animal heat. This led me to construct in my own mind a theory of the mode of action of the carbohydrates, a theory which is very satisfactory to me as presenting information in regard to diabetes, a subject which I have carefully studied, and the pathology of which is most unsatisfactory.

It seems that all of the sugar taken as food and the sugar which results from the digestion of starch, when taken into the circulation, can not be digested or used in the system at once. The carbohydrates of food are taken in at stated times and in the course of two or three hours are absorbed. They are destined to be used in a process which is coexistent with the general process of nutrition and appear to be specially concerned in the production of heat. For the reason that these substances

are to be used in this gradual manner, they must be stored up somewhere; and it has been shown that they are taken to the liver and there converted into glycogen. My idea is that the glycogen thus stored up is slowly and gradually, as it is needed, converted into sugar and passed out of the liver into the hepatic veins and that thus a small quantity of sugar is always passing into the circulation; that this sugar is rapidly converted into alcohol which is readily oxidized; and this is the way in which the carbohydrates are consumed and concerned in the production of animal heat.

Again, what becomes of the sugar and starch of food if it is not stored up in some part of the organism? In cases of diabetes sugar is discharged in the urine; and in these cases the temperature of the body is nearly always subnormal. In these cases, also, there is progressive emaciation, because the substance of the tissues is used in the production of heat. I have carried out this theory in regard to diabetes to this extent: that I have calculated the sugar discharged in twenty-four hours and its equivalent in alcohol, have given patients alcohol in small divided doses and brought the temperature up to the normal standard.

In regard to the effects of alcohol, there is no doubt of one thing: that alcohol, whenever it produces the phenomena, greater or less in degree, of alcoholic intoxication, circulates as alcohol in the blood. I am ready to assume that in health alcohol is never useful, but when given in disease, if my view in regard to the digestion of the carbohydrates stored up in the liver is correct, it is in the form in which the carbohydrates would exist if the system were able to store them up in the liver to pour them out in the proper quantity and at the proper time; but when there is the slightest symptom of alcoholic intoxication, this is evidence that alcohol is circulating in the blood and it is time to stop or give it in small quantities.

The proper rules for the administration of alcohol in fevers seem plain and unmistakable. The only question is: "Does feeding the fever in this way increase the pyrexia or does it not?" It does not increase it; and often it largely diminishes the pyrexia. Of course the quantity

of alcohol that is thus given is to be measured by the occasion. Every practical physician knows that in most cases of typhoid fever it is not necessary to give alcohol early and that it is not necessary to give it very largely; but in certain cases it may be necessary to give it so largely as to reach the extreme that I have mentioned in my paper.

I do not assume to give an explanation of the mechanism by which microörganisms produce fever; I simply desired, in my address before the International Medical Congress, to take fever as it is typically represented in typhoid fever and to ascertain, if possible, why certain measures of treatment exert a favorable influence on the course and termination of the disease.

XXV

ON SOME OF THE THERAPEUTIC USES OF ALCOHOL

Published in "The Medical Register" for February 26, 1887.

ALCOHOL is capable of producing two entirely distinct effects upon the system, especially when taken by those who do not use it habitually.

Taken by a person in perfect health, well nourished and not subjected to any abnormal conditions, a small quantity of alcohol produces a certain degree of nervous excitement; and a considerable quantity induces, in a more or less marked degree, the well-known phenomena of alcoholic intoxication. These effects are due to the circulation in the blood of actual alcohol; and they continue until the alcohol is either destroyed or eliminated. This is one of the effects of alcohol which it is seldom if ever necessary or desirable to produce in the administration of this agent in disease; and it is questionable whether alcohol is ever useful as a beverage under conditions of perfect health and proper nutrition.

In certain pathological conditions, a moderate and sometimes a large quantity of alcohol may be administered without producing any appreciable excitement, much less evidences of alcoholic intoxication. Notwithstanding this, the alcohol has a certain effect, although this effect is quite different from that produced when it excites or intoxicates and when it exists as alcohol in the circulating fluid. It is in regard to this second effect of alcohol, unattended with what may be called its toxic manifestations, that I propose to present certain physiological and clinical reflections.

As to the effects first mentioned (alcoholic excitement or intoxication) these are easily recognized and are a sure

guide to the administration of alcohol in disease. When these effects are apparent in the slightest degree, alcohol is either contraindicated or the quantity administered has been too large.

In 1872 a paper on the "Normal Presence of Alcohol in the Blood" was published by Dr. William Hutson Ford, then of New Orleans.* Since the discovery of the glycogenic function of the liver by Claude Bernard, the final destination of sugar in the economy has been an important subject of discussion. That the sugar produced in the body and that introduced with the food and resulting from the digestion of starch disappears as sugar and is not discharged, there can be no doubt. The theoretical modes of its destruction are by the lactic acid and the alcoholic fermentation, either singly or both combined.

There is no positive experimental basis for the theory that the carbohydrates undergo lactic acid fermentation in the body. Dr. Ford demonstrated the presence of a small quantity of alcohol in the normal blood, using for his analysis large quantities of the fresh blood of the ox. Reasoning from this as the main fact, Dr. Ford came to the conclusion that the carbohydrates are gradually and constantly undergoing alcoholic fermentation, that the alcohol thus formed is oxidized as fast as it is produced, and that in this way the carbohydrates act as important factors in the production of animal heat. My reflections and observations have led me to adopt this view provisionally, admitting, however, the possible formation of a certain quantity of lactic acid, although this lacks experimental proof. My confidence in this opinion is strengthened by facts and observations relating to disease.

In fever there is an excessive production of animal heat at the expense of the solid tissues, as is shown by the pyrexia, the loss of body-weight and the parenchymatous degenerations.

In the constant elevation of the body-temperature observed in progressive pulmonary tuberculosis, there is destruction of tissue and consequent loss of body-weight.

In diabetes mellitus, in which sugar is not destroyed in nutrition but is discharged as a foreign substance in the

* "New York Medical Journal," June, 1872.

urine, there usually is a reduction of the general temperature of the body.

In fevers alcohol, judiciously administered, is useful in supplying matter for consumption in the excessive production of heat, thereby saving the tissues from destruction and degenerations. Thus administered it does not increase the pyrexia, but it sustains the strength of the patient and produces no degree of alcoholic intoxication.

In certain cases of pulmonary tuberculosis alcohol is remarkably tolerated and probably acts in the same way as in fevers.

In pathological conditions, chiefly in acute diseases, in which alcohol is useful, it acts as a representative of the carbohydrates, in a form in which it is readily absorbed and oxidized, requiring no preparation by digestion. In this way the carbohydrates may be introduced, when the digestive function is impaired, in a form which may be compared to the condition of peptonized nitrogenous food. In its action, under these conditions, it is a carbohydrate food, promptly oxidized and not circulating as alcohol in the blood.

If it can logically be assumed that a part even of the carbohydrates is changed into alcohol and is oxidized in nutrition, there can be no moral objection to the judicious administration of alcohol in therapeutics any more than to the administration of sugars and starches.

The advantages of careful administration of alcohol in certain cases and in certain stages of fever have long been recognized and admitted on the basis of clinical experience. As regards the theoretical advantage of alcohol in diabetes mellitus, in which the discharge of sugar from the body is attended with a diminution in the animal heat, I copy from my note-book the following memorandum, of the date of November 15, 1886:

"Assuming that starches and sugars contribute to the production of animal heat by being converted into alcohol and that the alcohol is oxidized in the body, the loss of sugar might be compensated by the introduction of the quantity of alcohol which the sugar lost would produce if converted into alcohol in the body. One grain of sugar used in forming carbonic acid and alcohol would produce about one-half grain of alcohol and about one-half grain

of carbonic acid (180 weight of sugar = 92 alcohol and 88 carbonic acid). For every grain of sugar discharged give one-half grain of alcohol, or one grain of brandy or whisky containing about fifty per cent. of alcohol. The weight of one fluidounce of brandy, specific gravity 0.93, = 446.4 grains, counting one fluidounce of water as equal to 480 grains."

In two cases of diabetes of long standing, now under my care, in which a cure can not be effected, the object of treatment being to produce a tolerance of the disease, I have given, in small doses, a quantity of whisky exactly equal to the weight of sugar discharged daily. In one of the cases, in which I have been able to follow the changes in temperature, the temperature under the tongue was $97\frac{1}{4}°$ Fahr. on December 15, 1886. After taking four ounces of whisky daily for eight days, the temperature, on December 23d, was 98°. I shall employ this treatment in other cases in which the glycosuria can not be arrested, in the hope that the supply of alcohol to compensate the discharge of sugar may bring the temperature of the body to the normal standard and contribute to a tolerance of the disease.

XXVI

ADDRESS ON SOME OF THE RELATIONS OF PHYSIOLOGY TO THE PRACTICE OF MEDICINE

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PHYSIOLOGY is the logical basis of scientific medicine; even if the term medicine is used in its widest signification, and is made to include the practice of surgery, obstetrics and gynecology. While therapeutics has always been more or less empirical, the results obtained by the purely experimental exhibition of drugs, when the value of such agents has been established by clinical observation, have nearly always been explained by researches conducted in accordance with the methods most successfully employed in physiological investigation. Illustrations of the principles of harmony years ago, in the musical compositions of Bach and Beethoven, were as purely the results of empirical methods as the treatment of miasmatic fevers with quinine or of syphilis with mercury. As the comparatively recent mathematical investigations of Helmholtz have established a physical basis for the laws of harmony and modulation, so exactly followed by the early classical composers, so the rationale of what was formerly empirical therapeutics becomes positive and definite, as knowledge advances in the direction of the modus operandi of medicinal agents and the morbid modifications of physiological processes, which constitute disease.

Although anatomy and to a certain extent animal chemistry have an existence separate and distinct from physiology, physiology itself can not be divorced from a knowledge of the structure, relations and composition of parts of the body; although it may be empirically or even accidentally ascertained that a certain drug will

cure a certain disease, the rational treatment of diseases, in their various phases and modifications, can not be employed without a knowledge of pathology based on facts drawn from physiology; and while a practitioner of medicine may meet with some success in using prescriptions which are said to be "good" for certain maladies, he rises but little above the avowed "empiric" when he fails to make use of "the aids actually furnished by anatomy, physiology, pathology and organic chemistry."

The relations of physiology to the practice of medicine, surgery and obstetrics constitute a subject much too large for discussion within the time to which this address is necessarily limited; and I shall be forced to content myself with a brief review of a few, only, of the most striking applications of anatomy and physiology to the everyday practice of the physician, leaving out of consideration surgery and obstetrics—a great part of the latter being in itself pure physiology. It may be stated, however, as a general proposition, that the more familiar and trite the examples of the dependence of the pathology and treatment of diseases upon physiological knowledge, the more complete and perfect are they as illustrations of the practical applications of the study of normal functions.

It is difficult to imagine the existence of a rational pathology anterior to the discovery of the circulation of the blood. The method of study illustrated in the classic work of Harvey did not immediately influence physiological research in other directions; but a review of the important physiological discoveries made since 1628 shows that the experimental method, which led to such brilliant results in the hands of Harvey and which was formulated in the Baconian system of philosophy, has been the only one which has stood the test of time. The indirect applications of this method to practical medicine are too many to be even enumerated here. They are to be found both in ancient and modern medicine. The physiological facts handed down from Aristotle were ascertained by the experimental method. It was direct observation and experimentation that enabled Galen to show that the arteries carry blood instead of air. The correct anatomical description of the heart by Vesalius, and the demonstrations of the valves of the veins by Étienne, Cannanus,

Eustachius, Piccolhomini and Fabricius, prepared the way for the discovery of the circulation by Harvey. The discoveries by Legallois, Prochaska, Magendie, Marshall Hall, Flourens, Bernard, Brown-Séquard, Fritsch and Hitzig and others, have afforded a positive basis for the pathology of nervous diseases. It is almost unnecessary to recall the observations of Prevost and Dumas on the kidneys, of Beaumont, of our own country, on the gastric juice, of Bernard, on the pancreas, and other physiological discoveries which have, directly or indirectly, so greatly enlarged the boundaries and added to the accuracy of pathological knowledge. An application of methods which have been known to be so useful in physiological study to the investigation of disease is daily producing definite and trustworthy results, although much time elapsed before these methods were generally adopted. The observations of Louis, which were published early in the second quarter of the present century, have exerted a profound and lasting influence on medical progress. The so-called numerical method, employed by Louis in the study of phthisis, fevers and other diseases, was strictly in accordance with the methods of scientific investigation which had done so much for physiology. Physiological discoveries had been made by patient experimentation directed by intelligent preliminary notions, the experimental facts developed always controlling the preconceived theories. Diseased conditions may, indeed, be regarded as experiments made by Nature on the human organism. In the interpretation of these conditions, a variety of disturbing elements, not present in most experiments upon animals, are to be considered. An accurate record of a large number of cases of any given disease, these cases being analyzed with reference to causation, symptoms, duration, post-mortem appearances, the influence of remedies and of peculiar circumstances and idiosyncrasies, affords a truly philosophical basis for correct ideas of pathology, treatment and prognosis. When this is supplemented with a study of the natural history, or the physiology of the disease, and its natural course is studied without therapeutic interference, positive knowledge is limited only by opportunities for investigation and the accuracy of instruments and methods of examination.

About the year 1845 Lebert published a work with the apparently contradictory title of pathological physiology. There is indeed a pathological physiology; physiology being the science of Nature, and pathological physiology the natural history of disease. When, as a result of the study of the natural history of any given pathological process, it is ascertained that the disease is self-limited and has a natural tendency to terminate in recovery within a certain time, the physician is in a position to judge of the effects of remedies and to contribute intelligently to a favorable result. At the present time there are many grave diseases in which therapeutic efforts are almost exclusively in the direction of preventing suffering, ameliorating symptoms and maintaining the natural forces until the malady shall have run its course; but it is none the less a duty constantly to strive to ascertain the causes of morbid processes and their exact pathology, with the view of aborting or of actually curing diseases. Modern investigations have already made great advances in these directions.

Physicians, in their relation to patients, are looked to for the relief and possible cure of the ailments which they are called upon to treat. As a rule patients feel but little concern in the methods by which a physician arrives at the special knowledge which makes him useful in each individual case; and they generally look only at results. Assuming that the physician is in possession of the fullest and best information concerning anatomy, animal chemistry, and physiology, the first step in the logical process which results in the application of proper therapeutic measures is the establishment of an accurate diagnosis. I need hardly insist here upon the importance of this as an essential condition of the intelligent treatment of all diseases; and it is not too much to say that a thorough knowledge of anatomy and physiology is the most important of the many requisites of a skillful diagnostician. One of the best illustrations of this proposition is in the applications of anatomy and physiology to the diagnosis of diseases of the heart.

Without attempting anything like a complete historical review of the progress of our knowledge regarding the physiology of the action of the heart, I may be per-

mitted, perhaps, to call attention to the succession of certain important facts ascertained by anatomical, physiological and pathological researches.

The errors of the ancient anatomists were pretty thoroughly corrected by Vesalius, whose anatomical descriptions of the heart, including the valves, were quite complete. Notwithstanding this, many years elapsed before Harvey described the blood-currents and demonstrated the uses of the valves. Although Harvey gave a brief description of the sounds of the heart, it was about two hundred years after the discovery of the circulation of the blood that Laennec made an attempt to define their succession and rhythm in the human subject. Laennec, however, had no correct idea of the mechanism of the heart-sounds, and consequently lack of physiological knowledge still retarded progress in the diagnosis and pathology of cardiac diseases. A few years later Hope indicated clearly the relations of certain abnormal heart-sounds to pathological conditions; and researches since his time have rendered the recognition of most of the structural diseases of the heart one of the simplest problems in physical diagnosis. The certainty with which the exact nature of valvular and other lesions of the heart can now be ascertained has been largely the result of close study of the heart-sounds in health.

In physical exploration of the heart it is easy enough to ascertain the exact situation and character of the apex-beat. If this is displaced in certain directions (leaving out of consideration rare congenital peculiarities and malpositions due to pleuritic effusions or other extraneous causes that are readily recognizable) the heart must be of abnormal size. Assuming that the base of the heart is fixed, the apex can not be moved downward and to the left without enlargement of the organ. The kind of enlargement, whether by hypertrophy or dilatation or both, may be measurably determined by the character of the impulse; while the fact of enlargement may be confirmed by determining the extent of the area of cardiac dullness. The object of the ventricular systole is to send the blood from the left side to the system, and from the right side to the lungs. Confining the illustration to the left ventricle, it is evident that a heart with hypertrophied walls

must beat with increased power, must close the auriculo-ventricular valves with abnormal force and must unduly distend the aorta. This simple modification of the physiological action of the heart must, therefore, exaggerate the apex-beat and increase the intensity of the first sound, and the vigorous reaction of the elastic aortic walls must produce an increased intensity of the second sound. These being the sole physical signs, the condition must be that of simple hypertrophy. If on the other hand, the apex-beat is indistinct and diffused, and the first and second sounds are enfeebled, it is evident that the walls of the ventricles are unable to discharge the contents of the cavities efficiently and normally. The heart is enlarged, but its action is not increased in vigor. The quantity of blood which it receives is increased without a corresponding increase in the force of its action. The condition must be that of dilatation, without a corresponding increase in the thickness of the ventricular walls.

Experience has taught that the most frequent causes of enlargement of the heart are referable to persistent obstruction or modification of the blood-currents through this organ; and pathological investigations have shown that these obstructions or modifications are to be looked for at the orifices. One thoroughly conversant with the physiological action of the heart and the normal character of the heart-sounds can readily recognize the element of the first sound due to the sudden closure of the curtains of the mitral valve, by applying the stethoscope to the precordia, a little to the left of the left nipple. If the sound is unaccompanied with any abnormal sound, if there is no murmur immediately preceding the first sound as heard in this situation, and if the element due to the closure of the valve is perfectly pure, it is certain that the auriculo-ventricular orifice is normal and that the action of the mitral valve is perfect. It is well known that the first sound, which is synchronous with the ventricular systole, is produced in part by the closure of the mitral valve; if, however, the first sound is attended with a murmur heard with its maximum of intensity directly over the mitral valve, it is almost certain that the valve is insufficient and that there is regurgitation at the mitral orifice. If a murmur is heard immediately preceding the first

sound and ceasing abruptly at the beginning of the first sound, inasmuch as the blood at that instant is passing from the auricle through the mitral orifice into the ventricle, it is evident that there must be stenosis or roughness at the auriculo-ventricular opening. I have said, with a reservation, that a mitral systolic murmur indicates mitral regurgitation; for the reason that roughness of the ventricular face of the valve sometimes produces an abnormal sound when no mitral regurgitation exists.

It is certain that the second sound of the heart is produced exclusively by a sudden closure of the semilunar valves, immediately following the cessation of the ventricular systole. Placing the stethoscope over the aortic orifice a little to the right of the upper part of the sternum, it is easy to recognize the sound produced by the normal closure of the aortic valves. During the first sound, the contraction of the ventricles closes the auriculo-ventricular valves, opens the semilunar valves, and the blood is passing from the left ventricle into the aorta. If a murmur is heard directly over the aortic orifice, accompanying the first sound of the heart, it is certain that this opening is constricted or its sides are roughened. If a murmur is heard over the aortic orifice, accompanying the second sound of the heart, it is equally certain that the valves are insufficient and that there is aortic regurgitation.

An accurate knowledge of the physiology of the heart is most useful in enabling the physician to estimate the danger to life arising from the conditions indicated by physical signs. The most important office of the left ventricle is to carry on the systemic circulation by means of its regular and efficient contractions. The danger of lesions at the cardiac orifices or of damage to the valves is by no means to be measured by the intensity of murmurs. A loud murmur may not be of much immediate importance, and a low, soft murmur, only, may be heard, when the condition of the heart is very serious. The danger to life is indicated by the degree to which the functions of the left ventricle are impaired and are likely to be impaired. When an obstructive or regurgitant lesion is so considerable as constantly and seriously to interfere with the normal blood-currents, the heart becomes pro-

gressively dilated and the valvular quality of the sounds is less and less distinct and may be lost. The degree of dilatation is to a great extent a measure of the probable impairment of the functions of the heart; and the organ, receiving an abnormally large quantity of blood and being incapable of efficient contractions, may, under temporary conditions which call for unusual vigor of contraction, fail in its action.

I have brought forward thus prominently the illustration of the application of cardiac physiology to practice, for the reason that pathology affords no more striking instance of the importance to the physician of a thorough knowledge of normal functions. When a student has fully mastered the physiology of the heart, when he has become capable of recognizing and differentiating the heart-sounds and can connect these sounds with the blood-currents, when he understands the mechanism of the production of the heart-sounds and the action of the different sets of cardiac valves, the recognition of cardiac lesions is simple enough; but without this physiological knowledge, the pathology of diseases of the heart is to him a sealed book written in an unknown tongue.

Primary diseases of the digestive system, which come under the care of the physician as cases of indigestion or dyspepsia, constitute a class of disorders which it is not easy to treat intelligently. Civilization involves a large disregard of hygienic laws, both as regards alimentation, judicious exercise, exposure, rest and mental work. A man (and such men are few) whose only care in life is to live temperately and rationally, and whose only ambition is to enjoy the luxury of perfect health, is not likely to do much for humanity or to advance knowledge and the general welfare of his kind. Those who are compelled to struggle for existence and comfort, who seek to acquire wealth or distinction, who work and investigate in search of knowledge or who have grievous burdens, seldom live strictly in accordance with natural laws. Those who have attained their worldly ends and who abandon their occupations in the hope of repose and tranquil happiness for the remainder of their days, without occupation and devoid of mental resources, are frequently the victims of real or imaginary disorders which often assume the form

of disturbances of digestion. The history of medicine does not show that the human race has ever been free from dyspepsia, at least in civilized countries; and there is no disease in which purely empirical measures, either recommended by the physician or resulting from the personal experience of the sufferer, are so disappointing and inefficient as in this.

It is not too much to say that a definite knowledge of the physiology of digestion had its origin in the researches of Dr. Beaumont, made in this country between the years 1825 and 1836; and it a self-evident proposition that physicians can not understand and intelligently treat cases of disorders of digestion without a thorough knowledge of the physiology of the digestive organs. The application of physiology to practice in such cases was so apparent, that one of the first efforts of Dr. Beaumont was to establish the degree of digestibility of different articles of food, which resulted in the table which has been so extensively quoted in works on physiology.

Following the observations of Beaumont (1825–1836), are the researches of Blondlot, Bernard, Lehmann and a host of others, on stomach-digestion; the investigations of Leuchs, Miahle and others, on the saliva; the discovery of the functions of the pancreatic juice in 1848, by Bernard, and later researches on the digestive functions of the bile and the intestinal juice. If the idea of some of the older physiologists, that the saliva digests starch, the gastric juice the proteids, the pancreatic juice, with the aid of the bile and the intestinal juice, the fats, had been verified by exact observations, it would have been easy to locate digestive disturbances and to apply the proper physiological remedies. Unfortunately, however, the normal digestive processes are not so distinct and simple. Saliva is incorporated with the food before it passes into the stomach; and as the alimentary mass goes gradually and slowly into the small intestine, it carries with it saliva and gastric juice and meets with a mixture of bile and pancreatic juice, being exposed to the action of the intestinal juice as it moves toward the ileocecal valve. The process of digestion, indeed, is complex, and the combined and successive action of the different digestive fluids is not yet thoroughly understood. Still, fol-

lowing a knowledge of the normal processes, the judicious use of peptonizing agents in cases of dyspepsia has often been attended with satisfactory results. The more extensive and accurate the knowledge of the physiology of digestion, the more successful will the physician be in treating diseases of the digestive organs. In this class of disorders practice of medicine must wait on physiology.

It would be more than tedious to enumerate the errors in practice handed down from age to age, which have been corrected by advances in knowledge of physiology. The exclusive systems of pathology, most of which now possess nothing more than an historical interest, have all yielded to the march of physiological science. The classical notion of the action of mercury on the liver has succumbed to physiological researches. No exact knowledge of the modus operandi of remedies through the blood was possible before the discovery of absorption by blood-vessels, made by Magendie in 1809. The localization of diseases of the encephalon, and a knowledge of the pathology of the host of diseases of the nervous system which the physician is called upon to treat, are directly dependent upon the physiological observations of Magendie, Bell, Flourens, Müller, Marshall Hall, Bernard, Brown-Séquard, Longet, Fritsch and Hitzig, Ferrier and other physiologists of the present century. The discovery of the mechanism of excretion by the kidneys, made by Prevost and Dumas in 1821, rendered possible an intelligent pathology of renal diseases, first indicated by Richard Bright in 1827. I may, perhaps, be permitted to include the description of an excretory function of the liver, in 1862, which throws some light on hepatic pathology. Although the pathology of diabetes mellitus is still obscure, the only definite information on this subject is derived from the discovery of the sugar-producing function of the liver, made by Bernard in 1848.

Within a few years physicians have given much study to the relations of the temperature of the body to disease. Nearly all medical practitioners now make constant use of the clinical thermometer, and variations in body-temperature are carefully watched and give important information bearing on diagnosis, prognosis and the effects of treatment. Various medicinal agents have been found to

exert a marked influence on the heat of the body; and some therapeutists direct their efforts toward bringing the temperature within the normal range of variation by the administration of drugs which are supposed to influence the heat-producing processes. It is now generally recognized that fever invariably involves an elevation in the temperature of the body, as indicated by the thermometer. Whatever may be the correct views in regard to the propriety of attempting to directly influence fever as a single symptom of disease, it is certain that a return to the normal standard of body-temperature in the essential fevers, when not produced by the action of antipyretics, surely indicates a diminished intensity of the morbid processes. Leaving out of the question for the present the subject of the causation of fevers, the relations of the physiology of animal heat to the symptom known under the name of fever are most important and interesting.

Positive knowledge of the physiology of animal heat dates from the experiments of Lavoisier and Laplace, made in 1777. It is now known that the body is kept at a nearly uniform temperature by the general processes of nutrition, involving largely oxidation, either direct or indirect, of materials supplied by food, the most active heat-producing articles being compounds of carbon, hydrogen and oxygen. The condition known as fever involves an exaggeration of the normal heat-producing processes; and if this condition persists for a certain time, it is attended with loss of body-weight, most marked in the fatty tissues. The fever seems to consume the body itself, especially as there generally is a distaste for food and the efficiency of the digestive functions is temporarily impaired. These conditions are observed in nearly all cases of continued fever and of diseases in which there is a constant elevation of heat of the body.

In a paper on "Animal Heat," published in the "American Journal of the Medical Sciences," in April, 1879, I advanced certain views relating to the treatment of fevers, based directly upon knowledge of the physiology of animal heat. The reflections contained in this paper afford another illustration of the relations of physiology to the treatment of disease.

"It is evident that in normal nutrition by food, the heat of the body must be maintained by changes which take place, either directly in the blood or indirectly in the tissues or in the alimentary matters, and that these changes involve oxidation to a very considerable extent. Under ordinary conditions of nutrition it is assumed that the food furnishes all the material for maintaining the heat of the body and for the development of force in work, such as the muscular work of respiration and circulation and general muscular effort. If no food is taken for a certain time, the heat of the body must be maintained and the work must be accomplished at the expense of the substance of the body itself; and the individual loses weight."

In the instance of a continued fever unattended with any complicating conditions, the heat of the body is increased, little food is taken and the functions of digestion and assimilation are more or less impaired. There is an excessive production of heat and the material for the supply of heat by food is greatly diminished. Under these conditions the tissues are themselves consumed and the body loses weight.

A continued fever is a self-limited disease. Within a certain number of days the morbid processes run their course. Assuming that the disease is not arrested and that it must continue for a certain definite period, there are two important objects to be attained by treatment: One is to moderate the excessive production of heat, and the other is to so far save the tissues, by artificially supplying heat-producing material, as to preserve them to such an extent that the system shall be in a condition to recuperate when the fever shall have come to an end. How far, now, can a knowledge of physiology aid the physician in the rational treatment of those fevers which clinical experience has shown to be temporary and self-limited!

Under perfectly normal conditions, the body-weight being stationary, the matter consumed in the production of animal heat must be derived from food. Making deductions for certain products which pass out of the body and do not contribute to the production of heat, the actual heat-value of different articles of food has been calculated. In these calculations, however, no account has been taken of the heat produced by the union of oxygen and hydrogen to form water in the body; but by a series of experi-

ments, published in 1879, which it is not necessary to detail, I succeeded in establishing the fact, to my own satisfaction at least, that water may be produced in the body by the union of oxygen with hydrogen, which would of course involve a very considerable development of heat. Assuming, now, a person to be in perfect health, neither losing nor gaining in weight, the body produces enough heat to maintain a uniform temperature of about 98.5° Fahr., and an excess sufficient to supply force for the various animal functions. This heat probably is due to processes of oxidation taking place in the blood and in the tissues, the normal standard of composition of these parts being maintained by the assimilation of food. When an excess of heat is produced under physiological conditions, the temperature of the body is kept at the normal standard by evaporation from the general surface. This is the physiological view of the regulation of the animal heat.

A person in the condition just described is attacked with typhoid fever. The temperature gradually rises until at the end of five or six days it has reached 103°. This abnormal production of heat continues, in the great majority of cases, for ten to twenty or more days; and within that time deficient assimilation of food involves a virtual burning up of parts of the body, there being notable loss of weight. In addition to measures which tend to actually diminish the heat of the body, if it can be assumed that the materials for the production of heat normally are supplied by food, it is certainly logical and rational to endeavor to feed the fever by heat-producing matters ingested, and thus save the tissues. Graves "fed fevers" long before there was established any physiological basis for such a method of treatment. He said that an important object was to prevent death from starvation. In that statement, however, this great physician was but partially correct. In so far as food can be supplied to the fever, in the same proportion are the tissues of the body saved. If certain articles of food that are known to have a high heat-value, such as the fats, can be digested and assimilated, they must serve in a measure to supply the excessive demand for heat-producing material and aid in husbanding the so-called vital forces.

The introduction of food when it is digested and assimilated by no means increases the intensity of the fever. On the other hand, as the fever probably depends on grave modifications in general nutrition, the supply of heat-producing matter from without may actually lower the temperature of the body. There can be no question of the great value of alcohol in certain cases of fever. It sustains the system and reduces the temperature. A knowledge of the physiology of animal heat leads readily to an explanation of the beneficial results so often following this use of alcohol. The heat-value of one ounce of French brandy is equal to about 400 heat-units. Twenty-two ounces of brandy have a heat-value equal to the heat produced by a healthy man in twenty-four hours; * and a patient may sometimes take with benefit an ounce, or even more, of brandy every hour for more than a day. It is not illogical to conclude that in a case of fever with a high temperature and great exhaustion, alcohol may supply the material for the excessive production of heat and thus preserve a patient until the fever shall have expended its force. In such a case alcohol may be given in large quantity without producing any evidence of its usual intoxicating effects. Ordinary alcoholic intoxication is due to the presence of alcohol in the blood. In cases of disease in which alcohol, although taken very largely, produces no such effects, the alcohol is undoubtedly consumed at once and remains but a short time in the circulating fluid.

There are conditions in which an abnormally high temperature exists without acute disease. In phthisis pulmonalis, for example, when the disease is progressive there is always more or less elevation of temperature.

It may be interesting to glance at some points in the history of pulmonary phthisis, studied from a purely clinical point of view, and to note how far the treatment which has been found most useful can be made to correspond with present ideas of the physiology of animal heat.

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* This calculation is based on the estimate of the production of two and a half heat-units per pound of body-weight per hour. The estimate in the original was for four heat-units.

The progress of phthisis is attended with loss of body-weight, disappearance of fat and an increased temperature. As a rule, when the temperature of the body becomes normal and when there is no loss of weight, the disease is not progressive. The main object of treatment is to arrest the disease. Although identical phenomena are not observed in all cases and the efficacy of special measures of treatment is not invariable, there are certain measures that are universally recognized as useful.

If the disease is uncomplicated and the tuberculous deposit is confined to the lungs, and if the digestive functions are not seriously impaired, aside from palliative measures directed to the cough, etc., the plan of treatment which experience has shown to be most useful is very simple:

An alimentation as nutritious as possible is the main reliance; and fats have been found to be especially useful. The efficacy of cod-liver oil, in the majority of cases, is universally acknowledged; and the benefit derived from the use of this remedy is probably not due in any great measure to the peculiar qualities of this particular oil, except in so far as it is readily digested and is an element of food superadded to an otherwise nutritious diet. While there are exceptions to all rules in the treatment of phthisis, alcohol in some form, used as a remedy and not convivially, generally is beneficial; and, to quote the expression of an authoritative writer on the practice of medicine, "phthisis is one of the diseases which, in certain cases, induce a remarkable tolerance of alcohol."

It is a remarkable fact that in diabetes mellitus (a disease in which starchy and saccharine elements of food are not assimilated but are discharged in the form of sugar in the urine) the temperature of the body is almost constantly below the normal standard. One of the most favorable indications of relief in this disease is a return of the temperature to the limits of health. It is fair to assume that the pathological condition which is attended with deficient assimilation of the carbohydrates involves a corresponding impairment of the heat-producing processes.

By far the most interesting and instructive of the many

examples to be found in the history of medical science of the close relations between physiology and the practice of medicine are those illustrating the application of recognized physiological methods to the study of disease. It is well known to physiologists that most of the great and important discoveries in this branch of medicine have resulted from experiments on living animals. Perhaps the greatest single discovery in medicine is that of the protective power of the cowpox against variola; and its benefits can hardly be overestimated. From time immemorial, inoculation with the virus of smallpox itself had been practiced in China, Arabia, Tartary, Circassia and other countries, with the general result of protecting the system by producing a mild form of the disease. Early in the eighteenth century, inoculation was introduced into England, chiefly through the efforts of Lady Mary Wortley Montagu, who had observed the practice in Constantinople, and the value of the operation soon became established on a scientific basis.

In June, 1798 Jenner published the first edition of his treatise on the cowpox. Seldom has a scientific problem been so thoroughly worked out, in all of its details, by a discoverer, as in the instance of the discovery of vaccination. Jenner traced the disease in the cow to a contagion derived from the heels of horses affected with "grease." He observed that persons who had been infected with the cowpox from milking diseased cows did not suffer from smallpox. He observed the fact that persons who had passed through smallpox did not usually become affected with cowpox. He also observed that persons who became diseased from dressing the heels of horses affected with "grease" usually were protected against the contagion of smallpox, although not so certainly as those who had experienced the cowpox.

In those days, inoculation with the virus of smallpox was a common procedure; and it was noted that persons who had passed through cowpox were not affected with smallpox, even after repeated actual inoculations with variolous matter. These observations led to a series of experiments, performed after the methods employed in physiological investigations, which established the fact that a trivial disease, running a short course and attended

with little constitutional disturbance, produced by inoculation from the vaccine pustules of a cow, afforded protection against what was then justly regarded as one of the most formidable of diseases.

The "Inquiry" of Jenner, resulting in the most momentous and beneficent discovery in medicine in modern times, was made by following out ideas derived from the observation of certain remarkable coincidences and by experiments made first upon living animals and afterward applied to the human subject.

It is the privilege of this generation to witness the inauguration of a revolution in medical science. Following upon the results obtained by a study of the natural history, or the physiology of diseases, the adoption by pathologists of certain methods, long employed in physiology, in the investigation of pathological problems is affording information of a positive and definite character hitherto unknown. I refer to recent observations in regard to the pathological relations of microörganisms.

Twenty years ago (in 1865) Villemin succeeded in producing a disease analogous to pulmonary tuberculosis, by inoculating rabbits and guinea-pigs with tuberculous matter; and the success which attended his experiments on these animals revived at once the old question of the contagiousness of phthisis.

In 1882 Koch made the most remarkable advance in pathology since the discovery of vaccination. By a series of investigations made after an entirely new method (the artificial culture of microörganisms) he succeeded in isolating the contagious organism of tuberculosis, now known as the bacillus tuberculosis. It is unnecessary to follow out the processes by which the microörganism characteristic of tuberculous disease was isolated and its pathological relations established. There is no discovery in medicine, within the recollection of the present generation, that has produced so profound an impression; and the readiness with which the conclusions arrived at by Koch have been adopted indicate alike the exact scientific character of the observations on which they rest and the high standard of culture of physicians of the present day. Followed, as it has been, by the demonstration of micro-

organisms characteristic of many other constitutional diseases, the discovery of the bacillus tuberculosis has opened a field of study that is yet in its infancy so far as practical results are concerned. The pathologist would be bold indeed who would venture to indicate the probable limits of the information to be derived in the near future from investigations of the same character as those made by Koch. The discovery of microörganisms which produce certain diseases must, in the course of time, lead to a knowledge of measures which will prevent or cure the diseases in question; and even now, the recognition of the bacillus tuberculosis is a positive and important factor in diagnosis.

I have thus ventured to draw from the great domain of pathology and the practice of medicine a few of the most striking illustrations of the relations of physiology to the positive knowledge which the practical physician daily uses in the diagnosis and treatment of disease. Physiological discoveries have made a scientific system of pathology possible. The greatest discoveries in the history of practical medicine have been made by the methods of investigation which have been found most useful in the study of physiology. One of these, the discovery of vaccination, is characterized as physiological, by its author, in the dedication of the second edition of his book to the King:

> "When I first addressed the public on a physiological subject, which I conceived to be of the utmost importance to the future welfare of the human race, I could not presume, in that early stage of the investigation, to lay the result of my inquiries at your Majesty's feet."

In the remarkable observations by Koch and his followers, the active principles of contagious matters were isolated, as physiologists have isolated the active principles of the digestive fluids. The methods of study were essentially those which have been most fruitful in results in physiology. Who can say that the processes of culture of microörganisms, now employed in pathology, may not be useful in physiological research; and that so-called physiological ferments, such as the active principles of the digestive fluids, may not be found to contain minute or-

ganisms upon the multiplication of which the peculiar properties of these substances depend!

In the advancement of medical knowledge physiology and pathology go hand in hand. The ideal physician is profoundly versed in physiology; and the ideal physiologist is no less deeply versed in the practice of medicine.

XXVII

EXAMINATION OF THE URINE OF APPLICANTS FOR LIFE-INSURANCE

Published by the Author for the use of Medical Examiners for Life-Insurance, in 1874.

In carefully selecting first-class risks for life-insurance, the medical examination should always include an investigation of the urine. This can be done most conveniently after the other steps of the examination have been completed; and if the result should lead the physician to decline the applicant decidedly on other grounds, it may not be necessary to examine the urine. So far as the necessary examination of the urine is concerned, the processes are easy of application and need occupy but little time. They are so simple that they can and should be employed in every examination.

I. Quantity.—The urine should be passed in the presence of the examiner in order to guard against error and fraud. The applicant should be asked if he passes urine in normal quantity and at proper intervals. The normal quantity is between thirty and sixty fluidounces, less in warm than in cold weather, and rather more in those who habitually take large quantities of liquids. The urine usually is voided on retiring to rest, on rising in the morning and two or three times in addition during the day. This is to some extent a matter of habit; and the frequency of micturition is variable. When there is a desire to pass the urine so frequently as to be troublesome, and particularly when this occurs several times during the night, there generally is some disorder of the kidneys or of the urinary passages. The statements of applicants on these points usually are sufficient for the information of the medical examiner.

II. Odor.—It is easy to note an abnormal odor in the

urine. An abnormally faint, a sweetish or a putrescent odor is readily recognized.

III. Reaction.—The reaction unless it is strongly alkaline is not very important. During the day the urine may be slightly turbid, faintly alkaline, neutral or acid, varying with the diet.

IV. Specific Gravity.—The normal range of specific gravity of the urine is between 1015 and 1025. A low specific gravity, 1005 to 1010, is not important in the absence of other unusual characters, particularly in cold weather and after taking liquids. When the urine is scanty the specific gravity should be high; and it should be low when the urine is abundant.

V. Albumin.—A sufficiently accurate test for albumin, for all practical purposes, is heat and nitric acid, applied as follows:

Add to a small quantity of urine in a clean test-tube a few drops of nitric acid; if this produces no cloudiness it is almost certain that the specimen does not contain albumin and it is not absolutely necessary to test by heat. If the urine becomes clouded or if there is a whitish opacity on the addition of nitric acid, boil another specimen in a clean test-tube; and if this also produces a whitish opacity, the urine contains albumin and the applicant is not insurable.

There are two points to be taken into account in testing for albumin. Some urine, containing an excess of uric-acid compounds, shows an opacity on the addition of nitric acid, due to a precipitation of amorphous urates. This disappears with gentle heat, so that the precipitate can not be mistaken for albumin, when the test is carefully made.

Alkaline urine containing a small quantity of albumin is not rendered turbid by heat. It is therefore necessary to note the reaction of the urine before testing it by heat. If it is alkaline, render the specimen acid by adding a few drops of acetic acid, when the albumin, if there is any, will be coagulated by boiling.

Urine that is alkaline or neutral may show a precipitation of phosphates on the application of heat, when it does not contain albumin. Such urine is cleared up by the addition of a few drops of nitric acid, so that this

precipitate can not be mistaken for albumin, when the test is carefully made.

A specimen of urine that presents an opacity on the application of heat which is not removed by acid, and a precipitation by nitric acid which is not cleared up by gentle heat, contains albumin.

VI. SUGAR.—The following test for sugar is absolutely certain. This requires three separate solutions:

Make a solution, in the proportion of 95 grains of sulphate of copper to a fluidounce of distilled water, and keep for use.

Make a solution, in the proportion of 379 grains of neutral tartrate of potash to a fluidounce of distilled water, and keep for use.

Make a solution of caustic soda in distilled water, of a specific gravity of 1.12, or $16\frac{1}{2}°$ Baumé, which can be prepared by any competent pharmaceutist, and keep for use.

Mix the above solutions for use in the following proportions: Take half a fluidrachm of the solution of copper; add half a fluidrachm of the solution of tartrate of potash; add of the solution of caustic soda sufficient to make three fluidrachms. Put a quantity of the mixture in a clean test-tube to the depth of about three-quarters of an inch. Boil the test-liquid, and when it is hot, add the urine drop by drop. If sugar is present, the addition of a few drops of urine will produce suddenly an opaque yellowish or reddish precipitate. If a volume of urine be added, drop by drop, equal to the volume of the test, and the mixture be brought to the boiling-point and then allowed to cool, without a precipitate, it is absolutely certain that there is no sugar.

In mixing the solutions, the addition of the tartrate of potash to the solution of sulphate of copper often produces a precipitate, which is cleared up when the solution of soda is added and the mixture is stirred. The mixture will keep for several days if protected from the air; but it becomes unreliable if kept too long. When the solution is unreliable, it will precipitate by simple boiling. In that event a new mixture of the three solutions should be made.

A convenient way to prepare the mixture is the fol-

lowing: Mark an ordinary test-tube with a file, so that the first mark will indicate one part of the solution of copper; another mark, the solution of potash (one part); and a third mark, the solution of soda (four parts). A test-tube marked with one line half an inch, a second line one inch, and a third line three inches from the bottom will answer. Mix and shake the solutions together. A portion of the mixture may be used for one test and the remainder will keep for several days.

If sugar is found in the urine the applicant is not insurable. When sugar is found the urine usually is of high specific gravity. It is rather unusual to find sugar in urine that has a specific gravity of less than 1020. Diabetic urine generally has a specific gravity of from 1035 to 1045.

If there are no symptoms leading to a suspicion of renal disease and if the urine contains neither albumin nor sugar and its general characters are apparently normal, kidney-disease and general disorders producing serious modifications in the urine may be excluded. In some cases of structural disease of the kidney, the urine is of low specific gravity and may contain microscopic casts and no albumin; but these cases are so rare, especially when there are no general symptoms of renal disease, that the neglect of a microscopical examination of the urine is not of importance in examinations for life-insurance.

As regards other points in the microscopical examination of the urine, pus, spermatozoids, blood, uric acid or urates, phosphates, oxalate of lime and other crystalline deposits can not occur, at least to such an extent as to render an applicant uninsurable, without being attended with symptoms that are readily ascertained by proper questions. It is not absolutely essential, therefore, to examine the urine of applicants microscopically.

SUMMARY

After having filled out the ordinary examination-blank ask the applicant to pass some urine.

Note the color, odor, specific gravity and reaction of the urine, and get an idea from the applicant of the total quantity in the twenty-four hours and of the frequency of micturition.

Test the urine for albumin with nitric acid and heat and test for sugar.

Remember that the urine, after taking largely of water and in cold weather, may have a specific gravity of even less than 1010; and yet this does not of itself indicate disease.

If the results of the above examination are satisfactory, the urine may be noted as normal.

Such an examination as has been indicated need not occupy more than a few minutes and should be made in every case of application for life-insurance.

The apparatus absolutely required is the following: A urinometer with a vessel to test the specific gravity; blue and reddened litmus-paper; a rack of test-tubes of convenient size; a marked test-tube or a graduated glass in which to mix the three solutions for the test for sugar; a solution of sulphate of copper, 95 grains to the fluidounce of distilled water, a solution of neutral tartrate of potash, 379 grains to the fluidounce, a solution of caustic soda, specific gravity 1.12 ($16\frac{1}{2}°$ Baumé), the three solutions in separate bottles; a bottle of nitric acid; a bottle of acetic acid; an alcohol-lamp or a Bunsen's gas-burner; a few glass rods; a convenient vessel to receive the urine. Keep the apparatus always clean and ready for use.

XXVIII

AN EASY METHOD OF ESTIMATING THE PERCENTAGE OF ALBUMIN IN URINE

Published in "The Medical News" for January 9, 1892.

IN "The Medical News" for December 19, 1891 is a letter on the "Maximum Percentage of Albumin in Urine," which calls attention to the confusion and inaccuracy of statements in regard to the proportions of albumin in urine. The only accurate method of determining the percentage of albumin in urine or in other liquids is to separate the albumin and then carefully wash, dry and weigh it. This process is tedious and often impracticable. The general practitioner needs a short and easy method that is fairly accurate, and it is very desirable that some such method should be generally adopted. I have been in the habit of using a simple and rapid process which yields comparative results that are sufficiently accurate for practical purposes. While I make no claim to novelty in the procedure, the fact that there is no single method in general use leads me to describe it as one that is convenient and requires no special skill in its application.

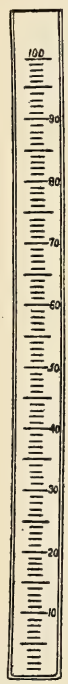


FIG. 1.

I have had constructed a tube, which the accompanying drawing (Fig. 1) represents about one-fourth of the actual size, with an arbitrary graduation up to 100. In a test-tube of convenient size, I boil a little more than half a fluidounce of urine to which have been added four or five drops of ordinary acetic acid. If the urine is turbid it may be filtered before being boiled. After thorough boiling and allowing the urine to cool for two or three minutes, it should be well shaken, in order to divide the precipitated albumin as finely as possible, and

then the graduation tube is filled to the 100 mark. After twelve hours' standing the percentage of precipitate is noted. The albumin will settle in twelve hours, and the volume of the deposit is not sensibly diminished if it is allowed to stand for twenty-four hours. The proportion of albumin measured in this way should be called percentage in volume of undried albumin.

This method is not exactly accurate but it is sufficiently so for ordinary purposes. It will indicate fairly well a proportion of one or two per cent. of albumin. When the proportion is less than one per cent., the ordinary method by contact or by simple boiling with a few drops of acetic acid would indicate "a trace" of albumin.

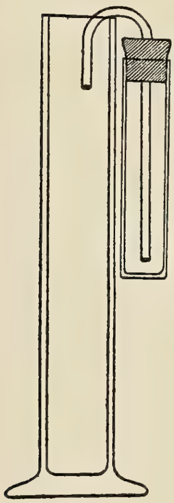


Fig. 2.

While writing on this subject, I am led to describe a simple apparatus for detecting the presence of sugar in the urine, when the results of Fehling's test are uncertain. The accompanying drawing represents the apparatus one-fourth size. A small straight bottle or a small test-tube is fitted with a cork, through which is passed a small tube that reaches nearly to the bottom. The glass tube is bent so that the apparatus will hang over an ordinary test-tube or other convenient vessel. (Fig. 2.) The bottle is completely filled with urine, with which a piece of Fleischmann's yeast about the size of a pea has been thoroughly mixed. In putting in the cork it is necessary to be careful to exclude every bubble of air. If the apparatus is kept for a half-hour at a temperature of 80° to 90° Fahr., a bubble of gas will appear if sugar is present in the smallest quantity. The apparatus may be placed in the sun or near a heater, but the temperature should not be higher than 100°. This is valuable as a negative test. In case of doubt I have often been able to determine absolutely the presence or absence of sugar before I had finished taking the history.

Procedures for the examination of urine, to be available in ordinary practice, must be short and easy, requiring little time and no great skill in manipulation; other-

wise examinations that may be important will be neglected.

In the hope of contributing something to the needs of the busy practitioner, I have ventured to make this communication. With the method I have described for the estimation of the percentage of albumin, Doremus's ureometer for determining the proportion of urea, and Roberts's "differential density" process for quantitative analysis for sugar, a chemical examination of the urine, sufficiently complete and accurate to meet the requirements of most cases, is easily within the reach of every physician.

XXIX

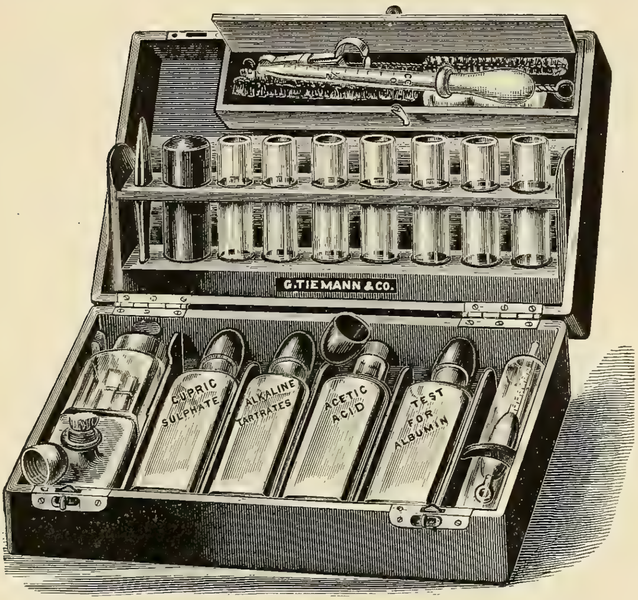
DESCRIPTION OF A PORTABLE CASE FOR CLINICAL EXAMINATION OF URINE

Published in the " New York Medical Journal " for July 16, 1892.

A SIMPLE portable case of apparatus for clinical examination of urine is certainly a great convenience; and the importance of facilities for prompt and accurate examinations in certain emergencies is sufficiently evident. Especially in consulting practice is it often felt to be essential to ascertain at once certain simple facts in regard to the urine, without the delay which so frequently is inevitable. To meet a want that I have long felt, I have devised a portable case, which will enable one to determine the reaction, specific gravity and presence or absence of albumin or sugar, with as little expenditure of time and trouble as would be necessary for an ordinary examination of the chest. I have thought that while the required apparatus should occupy the smallest space possible, it should be sufficiently complete and convenient to admit of an examination accurate and full enough for ordinary clinical purposes. It is impracticable, however, to determine at the bedside the proportion of albumin or of sugar or to settle the often delicate question of the presence and character of casts.

The woodcut represents the apparatus with the case open. The box is of hard-rubber, and when closed it measures six and three-quarters by four inches and is two inches deep. It can, therefore, be readily carried in the pocket or in a physician's bag. All parts of the apparatus are of rubber or glass, except the hinges, catches, test-tube holder and the alcohol lamp, which are nickel-plated. The cut gives a clear idea of its appearance. The reagents are Roberts's test for albumin, acetic acid, Squibb's two liquids used in testing for glucose and blue and red litmus

paper. The liquids are in glass bottles with paraffined cork stoppers and fitted with hard-rubber caps. A rack turns up to a vertical position when the case is open, and carries seven short test-tubes, a rubber forceps and a rubber match-box in a place that is to be used in taking the



specific gravity. The urinometer, in its paper case and glass for holding the urine, with the alcohol lamp are in the bottom section. The case also contains a clamp for holding a test-tube when the urine is boiled. In the top section is a compartment for a pipette graduated in tenths of a cubic centimetre, a large brush for cleaning the test-tubes, a drier for the test-tubes and a small brush for cleaning the pipette when necessary. In the top of the case are the following directions for use printed on a card:

Test for Albumin.—Fill a test-tube to the depth of about half an inch with the test-liquid—five parts of a saturated solution of magnesium sulphate and one part of pure nitric acid. Carefully introduce with the pipette about an equal bulk of urine, so that the urine will float

on the test-liquid. If albumin is present a white zone will appear between the two liquids. If the white zone should appear, control the test in the following way: Fill a test-tube nearly full of urine; add one or two drops of acetic acid (five per cent. solution of chemically pure acid); boil the top of the urine. If albumin is present the top of the urine will become cloudy (Roberts).

Tests for Sugar.—Introduce into a test-tube, with the pipette, 0.5 cc. of the solution of cupric sulphate (31.5 grains of pure cupric sulphate in an ounce of distilled water with one drop of sulphuric acid); then 0.5 cc. of water; then 0.5 cc. of the solution of alkaline tartrates (160 grains of Rochelle salt and 44 grains of caustic soda in an ounce of distilled water); finally, 0.5 cc. of water and shake the mixture without applying the finger to the mouth of the test-tube. Boil the mixture and allow it to cool slightly; then add 0.5 cc. of urine, boil and allow the mixture to cool. If sugar is present there will be a reddish or yellowish precipitate. If no sugar is present the mixture will remain clear and there will be no marked change in color (Fehling's test, modified by Squibb).

The apparatus is made by Messrs. George Tiemann & Co., 107 Park Row, New York city, and is filled by Dr. Edward R. Squibb, Brooklyn, N. Y., who supplies the urinometer, carefully tested, thus securing perfectly reliable reagents. Practically, I have found the case, even when used under disadvantages, nearly as convenient for the purposes to which it is applicable as a larger form of apparatus. When running water is not at hand, the test-tubes, urinometer, etc., may be thrown into a basin of water, cleaned, dried and put in place ready for use; and the time occupied in making an examination and cleaning need not be more than ten or fifteen minutes.

The fault in most forms of apparatus for examinations of urine at the bedside is that they are diminutive, inconvenient and not sufficiently accurate. I think the case I have described has the merits of accuracy and convenience; and certainly, if this is so, its use will prevent the omission of many examinations of urine, the results of which may be of great immediate importance. Few things are more useful to the busy practitioner than rapid and easy methods of physical examination.

XXX

ON THE ELIMINATION OF SULPHURETTED HYDROGEN ARTIFICIALLY INTRODUCED INTO THE BODY

Published in the "Medical News" for December 10, 1887.

THE observations which form the basis of this article were begun early last spring, shortly after the publication of the so-called Bergeon treatment of pulmonary phthisis by gaseous enemata; but unavoidable delay has deferred the completion of the experiments until now, when the interest in the subject has to a great extent subsided. Many articles, indeed, which have appeared in periodical medical literature within the last few months, have nearly covered the ground which I intended to go over, and I shall therefore consider the questions involved very briefly.

If it could be shown that a substance, innocuous as far as the human organism is concerned, could be introduced into the body and be eliminated by certain avenues, destroying in its passage morbific germs, the ideal treatment of many diseases would be to a great extent realized. If such a method were applicable to one class of diseases dependent upon the existence or multiplication of micro-organisms, it might logically be assumed that other diseases could be treated in the same way; and the possibilities of such measures of treatment could hardly be exaggerated. Inasmuch as many organisms which act as morbific agents must penetrate through the lungs, it would be natural to look for some germicide that would attack microörganisms in this situation; and the most effective way of reaching the materies morbi would be to introduce a germicide into the system by the alimentary canal or the subcutaneous tissue, provided it could be exhaled into the air-cells, and provided, always, that this could be done with safety. It was this idea, which logically

followed the assertions of Bergeon, that led me to make some experiments with sulphuretted hydrogen.

I proposed to leave out of the question for the present the apparent benefit derived by tuberculous patients from the treatment by gaseous enemata. The history of various so-called specifics for pulmonary phthisis shows with how much caution accounts of improvement in patients must be received. Much time must elapse and great numbers of cases, carefully observed under various conditions, must be recorded and analyzed before any positive conclusions can be reached as regards the results of any new method of treatment, particularly in this disease. Leaving, then, this consideration out of the question, I proposed to study the following problems:

I. Is sulphuretted hydrogen, introduced into the lower bowel, eliminated by the lungs?

II. Is sulphuretted hydrogen, injected in solution in water under the skin, eliminated by the lungs and can it be safely introduced in this way?

In various communications that have recently been published on the gaseous enemata it has been stated that sulphuretted hydrogen, mixed with carbonic acid gas and introduced in quantity into the large intestine, is eliminated by the lungs. Its detection in the expired air is very easy. A piece of white filtering paper, moistened with a solution of lead acetate and held before the mouth, will instantly reveal the presence of sulphuretted hydrogen in the breath, being discolored by the formation of lead sulphide. Gaseous enemata, after the method proposed by Bergeon, have repeatedly been employed in Bellevue Hospital. In many instances the breath has been tested during and after the enemata, but the characteristic reaction of sulphuretted hydrogen has never been observed. I made on May 2, 1887 a careful observation of this kind:

A man, thirty-two years of age, affected with pulmonary phthisis in the second stage, with considerable cough and expectoration, was the subject of this observation. He had been treated for some weeks with gaseous enemata and thought he had received some benefit. The enemata were employed in the usual way. A bag was filled with about a gallon of carbonic acid gas freshly

made and passed through a pint bottle of Sharon Springs sulphur-water, the emanations from which reacted promptly with lead acetate. Without giving in detail all the steps of the observation, I may simply say that during twenty minutes while the injection was continued, there was no elimination of sulphuretted hydrogen by the lungs. I then substituted for the natural spring water a bottle of a saturated solution of sulphuretted hydrogen in distilled water. During fifteen minutes of this injection there was no pulmonary elimination of sulphuretted hydrogen. The injection was then discontinued and the breath was tested at short intervals for an hour, always with negative results.

On May 5, 1887 I injected about half a fluidounce of a saturated solution of sulphuretted hydrogen in water into the rectum of a dog weighing 19 pounds. The breath was tested continuously during the ten minutes immediately following the injection, and then at intervals after the injection, as follows: 17, 25, 45, 60 and 90 minutes. There was no reaction of sulphuretted hydrogen.

On November 7, 1887 one fluidounce of a saturated solution of sulphuretted hydrogen in water was injected into the rectum of a dog of medium size, and the breath was tested continuously for a number of minutes immediately following the operation. In three minutes and twenty-three seconds the elimination of sulphuretted hydrogen began. This elimination continued for two minutes and fifty-three seconds, when it ceased. The reaction was distinct, but by no means so marked as when sulphuretted hydrogen is injected into a vein.

On April 25, 1887 I injected about one fluidrachm of a saturated solution of sulphuretted hydrogen into the stomach of a dog weighing 27 pounds, through a gastric fistula. This was not followed by the elimination of sulphuretted hydrogen by the lungs. Twenty-two minutes after the injection the dog urinated and part of the urine was obtained. The urine did not contain sulphuretted hydrogen.

In a number of experiments on dogs I injected about three fluidrachms of a saturated solution of sulphuretted hydrogen under the skin of the flank, and careful and frequent tests of the breath, repeated from the time of the

injection up to one or two hours after, at short intervals, failed to show the exhalation of sulphuretted hydrogen.

I have repeatedly injected sulphuretted hydrogen into the veins in dogs and have always noted a prompt elimination by the lungs; but this continues for a few seconds only, after the injection is discontinued. In an experiment made May 5, 1887 one fluidrachm of a saturated solution was injected into the external jugular vein of a dog weighing 22 pounds. Sulphuretted hydrogen appeared in the breath in three seconds after the injection was begun and disappeared almost instantly after the injection was discontinued. The animal suffered no inconvenience from the operation. This is a repetition of an experiment by Bernard, well known to physiologists. Bernard also injected sulphuretted hydrogen, about a fluidounce of a saturated solution, into the rectum of a dog. Elimination, in one experiment, began sixty-five seconds after the injection, but had ceased in five minutes.*

So far as these experiments bear upon the questions proposed at the beginning of this article, the following answers may be given:

I. Is sulphuretted hydrogen, introduced into the lower bowel, eliminated by the lungs?

In the single experiment on the human subject which I have described, and according to quite an extensive experience in Bellevue Hospital, sulphuretted hydrogen gas mixed with carbonic acid gas and injected according to Bergeon's method is not eliminated by the lungs. That it may be eliminated in small quantity under certain conditions is possible; but the quantity of gas thus thrown off must be very small. How far the carbonic acid acts as a vehicle carrying the sulphuretted hydrogen to the lungs, I can not say, as I have not found the sulphuretted hydrogen in the expired air.

In one experiment on a dog there was no pulmonary exhalation of sulphuretted hydrogen after the injection of half an ounce of a saturated solution in water into the rectum. There was a slight but distinct elimination fol-

* Bernard, "Leçons sur les effets des substances toxiques et médicamenteuses," Paris, 1857, p. 59.

lowing the injection of an ounce of a saturated solution into the rectum of a dog, the elimination lasting a little less than three minutes.

It appears from these observations, that a certain quantity of sulphuretted hydrogen introduced, even in saturated aqueous solution, may be destroyed in some way in the system without being eliminated as sulphuretted hydrogen.

II. Is sulphuretted hydrogen, injected in solution in water under the skin, eliminated by the lungs, and can it be safely introduced in this way?

My experiments show that such injections may be safely made, and that the sulphuretted hydrogen, thus introduced, is not eliminated by the lungs. I have no theory to offer as to the mode of its decomposition in the system.

Whether the Bergeon treatment of pulmonary phthisis is or is not useful, either as a palliative or as a curative measure, extensive clinical experience must decide; but the theories by which a supposed palliative or curative influence is explained have thus far no foundation in fact. Sulphuretted hydrogen, injected according to the method proposed by Bergeon, seldom appears in the expired air. When introduced in such quantity and in such a way that it is eliminated by the lungs, the time of elimination is brief, lasting a few seconds to about three minutes. It is hardly reasonable to suppose that this brief and imperfect exhalation of sulphuretted hydrogen can have any beneficial effects. If the assumed benefit is due to sulphuretted hydrogen, this agent must act in some way not connected with its elimination by the lungs.

Finally, according to the "Medical Record," the treatment of certain diseases by gaseous enemata is by no means new. "The rectal injection of 'fixed air' was recommended long ago by Priestley as of great utility in 'putrid diseases,' and Percival in 1768, and McBride in 1776, reported marvellous results from this method in pulmonary phthisis." *

* "Medical Record," August 13, 1887, p. 192.

XXXI

CREASOTE IN THE TREATMENT OF PHTHISIS PULMONALIS

Published in the " New York Medical Journal " for December 8, 1888.

In the summer of 1888, on entering upon my service in Bellevue Hospital, I noticed a number of patients in the wards of the third division wearing what are known as " perforated-zinc inhalers." For several weeks these patients had been treated with inhalations of creasote by a method suggested by Dr. Beverley Robinson. The improvement noted in these cases was so considerable that I directed the treatment to be employed in all the cases of phthisis pulmonalis in the male wards, with the exception of a very few in the last stages of the disease. A considerable number of cases did not remain under observation as long as two weeks. These cases are not reported. In the ten cases reported from the records, the treatment was followed for two or more weeks. In addition to the inhalations in all the cases reported, creasote was also administered by the stomach, and in some cases other remedies were employed.

The perforated-zinc inhaler is slightly modified by Dr. Beverley Robinson from an inhaler originally made by Squire, of London. Its simplicity and the ease and comfort with which it can be worn suggest its use in many diseases in which inhalations are of benefit. The following description of the inhalers is quoted from Dr. Robinson:

"They consist simply of a sheet of perforated zinc or tin, bent into a pyramidal shape and large enough to cover conveniently the nose and mouth. At the apex of the pyramid a bit of sponge is firmly held by means of strings in two bends in the margin of the zinc plate. Between the sponge and the mouth and nose there is a vacant space which obviates the stifling feeling which is so objectionable in the use of inhalers that are applied closely over the face. The inhaler is held in place by two narrow elastic bands, which pass around the ears. Before beginning an inhalation the sponge should be properly moistened with water or alcohol, and the inhaling fluid poured upon it." *

In the cases reported, the liquid used consisted of equal parts of creasote, alcohol and spirits of chloroform. Of this mixture, ten to fifteen drops were put upon the sponge. The treatment was begun with an inhalation of fifteen minutes' duration three or four times daily, increased until in some cases the inhalers were worn almost constantly except at night. There was no irritation produced by the inhalation, all the patients saying that after a few trials it relieved the cough and the irritability of the throat. In some cases in which the sweating at night was very profuse, atropin, $\frac{1}{96}$ of a grain, with fifteen drops of aromatic sulphuric acid were given at bedtime. In a number of cases in which the appetite was very poor a tonic, usually a mixture of iron, quinine and strychnin was administered before meals. In some cases in which the cough was very severe a palliative cough-mixture of spirit of chloroform, dilute hydrocyanic acid and syrup of wild cherry was used. No other medication was employed.

CASE I.—T. W., aged twenty-eight, laborer, was admitted May 19, 1888. The family history was negative. The patient has had cough with expectoration for the past five months, and has lost considerably in weight. He has suffered from night-sweats for the past few weeks. Three weeks ago he had considerable pain in the chest on the right side, followed by some fever and dyspnœa which have persisted. The temperature on the date of his admission to the hospital was 101.2° Fahr.

* Robinson, "A Manual on Inhalers, Inhalations and Inhalants," Detroit, 1886, p. 37.

Physical examination revealed the characteristic signs of pleurisy with effusion on the right side, that side of the chest being about half-full of liquid. A little clear effusion was taken with an exploring needle but the chest was not tappea. At the left apex there were signs of solidification, with fine and coarse mucous râles. Tubercle bacilli were found in the sputum and in the liquid taken from the chest with the exploring needle.

The patient was put on a tonic treatment, with a liberal diet. For a number of days the temperature was 100° to 103°, and once or twice it was 104° Fahr.

June 1, 1888.—In addition to the tonics and the liberal diet, the patient was given creasote, three drops three times daily, and an inhalation of creasote, spirits of chloroform and alcohol, equal parts, at first for a few minutes three times daily and afterward for four, six or eight hours during each day. The temperature was soon reduced to 99° or 100° Fahr., and after the middle of June it practically was normal. The patient was strong enough to be weighed only on June 23. At that date the weight was one hundred and thirty-two pounds. The liquid in the chest disappeared much more rapidly after the inhalations were begun than before.

July 20.—The patient left the hospital. There was no cough or expectoration and no sputum could be obtained for examination. There were no night-sweats and the patient said he felt as strong as he ever had been. There were still signs of solidification at the left apex, but the râles were very much less and were drier. The weight was one hundred and forty-three and a half pounds.

Case II.—J. H., aged nineteen, mason, was admitted June 19, 1888. The family history was good. The patient has had cough with expectoration and night-sweats but no hemoptysis. About six months ago, after "taking cold," he began to lose weight and has now lost about twenty-five pounds. The temperature was 104° Fahr. The appetite is very poor. Physical examination revealed the signs of cavities of moderate size at both apices, with mucous râles and gurgles. The patient was immediately put upon creasote, three drops three times daily and increased to four drops, with inhalations as in Case I., and whisky, ℥ ss. three times daily.

June 20, 1888.—The temperature was normal and the ward-tonic was substituted for the whisky. The weight on this date was one hundred and sixteen pounds.

July 18.—The patient left the hospital, much improved, with less cough and expectoration, diminished night-sweats and better appetite. The weight at this date was one hundred and twenty-five pounds. The physical signs were unchanged.

Case III.—T. B., aged twenty-one, porter, was admitted July 31, 1888. The family history was good. The patient had pleurisy two years ago. The present trouble began in December, 1887 with an attack of diarrhœa. He has had since that time cough and expectoration but no hemoptysis. He has night-sweats and some fever in the afternoon. He has lost thirty-five pounds in weight. The temperature was 99° Fahr. and the weight was one hundred and forty-nine pounds.

On physical examination there were found dullness, broncho-vesicular respiration, etc., with fine râles at the right apex. Tubercle bacilli were found in the sputum. The treatment consisted of creasote, three to four drops three times daily, tonic before meals and the usual inhalations.

August 25, 1888.—The patient left the hospital. He said he felt perfectly well. The cough had nearly disappeared and the weight was one hundred and fifty-nine pounds.

Case IV.—J. M., aged twenty-three, laborer, was admitted September 6, 1888. The patient has had cough with expectoration and one pulmonary hæmorrhage within the past three months. He has night-sweats and has lost some flesh. The appetite is very poor. The temperature was normal and the weight was one hundred and sixty-four pounds. Physical examination revealed signs of solidification at the right apex, with fine râles. There were some râles also at the left apex. The sputum contained a few tubercle bacilli. The patient was put upon creasote, four drops three times daily, and the usual inhalations.

September 22, 1888.—The cough and general symptoms were much improved. The weight was one hundred and seventy-four pounds.

Case V.—O. G., aged twenty-four, canvasser, was admitted June 23, 1888. Two sisters and a brother had died of phthisis. A year ago the patient had what he calls an attack of chills and fever and has not been well since. He noticed cough only within the past four or eight weeks. He had some expectoration, especially in the morning. He also had night-sweats and pain at the apex of the right lung. He had no appetite and had lost some flesh. The temperature was 99° Fahr., and the weight was one hundred and fifty-four pounds. Physical examination gave signs of slight solidification, with fine mucous râles at the right apex. The patient was put on the use of creasote, three drops three times daily, with the usual inhalations.

July 6, 1888.—The patient had a chill, with a temperature of 102° Fahr. Quinine, ten grains three times daily, was ordered for a few days.

July 30.—The weight was one hundred and seventy-four pounds. On this date the patient had a chill, followed by a temperature of 105.3° Fahr. He kept the bed for two or three days, with diarrhœa and fever, and at the end of that time his weight was one hundred and sixty pounds. He was then put on the use of a tonic three times daily, the creasote and the inhalations being continued.

August 25.—The patient says he feels perfectly well. He has no cough and all the symptoms have improved. The weight is one hundred and seventy-three pounds. There is no expectoration and no sputum can be obtained for an examination for bacilli.

October 1.—The patient has left the ward and works about the hospital. The inhalations have been continued. There has been no return of pulmonary symptoms. The weight is one hundred and seventy pounds. There are a few râles at the right apex.

Case VI.—J. C., aged forty, tailor, was admitted July 17, 1888. The father of the patient died of phthisis. The patient had a pulmonary hemorrhage ten years before. He has had cough, with whitish expectoration and night-sweats, for the past year. The temperature was 101° Fahr., and the weight was one hundred and fifteen pounds. Physical examination revealed a cavity at the right apex and slight solidification at the left apex. Tubercle bacilli were present in considerable number in the sputum. The patient was put on the use of creasote, three drops three times daily, with the usual inhalations.

August 25.—The temperature was normal and the weight was one hundred and twenty-one pounds. The cough was less and all the symptoms had improved.

Case VII.—J. S., aged forty, porter, was admitted July 23, 1888. The family history was negative. Since May last the patient had lost appetite, and has had cough, with at first a whitish expectoration. Subsequently the expectoration has at times been bloody. He had night-sweats, but no fever, and said he had not lost flesh. The weight was one hundred and fifty-six pounds. Physical examination revealed solidification, with fine and coarse mucous râles at the right apex. There were a few fine râles at the left apex. Tubercle bacilli were found in the sputum. The patient was put on the use of creasote, three drops three times daily, with inhalations. The mixture inhaled was composed of equal parts of creasote, spirits of chloroform, alcohol and tincture of iodine.

August, 14, 1888.—The patient left the hospital. All the symptoms had improved, and the weight was one hundred and sixty-four and a half pounds.

Case VIII.—P. M., aged thirty-one, plumber, was admitted July 31, 1888. The patient has had two or three pulmonary hemorrhages within the past six months. He had cough, with copious expectoration and night-sweats, and said he had lost fifty pounds in weight. The appetite was very poor. The temperature was 101° Fahr., and the weight was one hundred and twenty-one pounds. Physical examination revealed signs of solidification at both apices, with fine mucous râles. Tubercle bacilli were found in the sputum. The patient was put on the use of creasote, three drops three times daily, with the usual inhalations.

September 18.—All the symptoms were much improved and the weight was one hundred and thirty-four pounds.

Case IX.—P. B., aged twenty-eight, was admitted August 13, 1888. The family history was negative. The patient had been in bed for several days. He has had cough, with copious expectoration and profuse night-sweats, for nearly a year. He has had one pulmonary hemorrhage. Physical examination revealed cavities of considerable size at both apices. Râles of intercurrent bronchitis were heard over the entire chest. Tubercle bacilli were found in the sputum. The patient was treated with iron, quinine and whisky three times daily, and a cough-mixture, for three weeks.

September 3, 1888.—The patient was put on the use of creasote,

three drops three times daily, and the usual inhalations. All other remedies were discontinued except the quinine and iron.

October 5.—The only improvement in this case was some increase in strength. During the three weeks before the inhalations, he kept the bed, but afterward he was able to be about the ward. The cough is a little less troublesome and the expectoration is slightly diminished. The weight has remained about the same.

Case X.—P. C., aged twenty-four, was admitted July 7, 1888. The family history was good. The patient had pneumonia about ten years ago. He has had cough with expectoration and two or three pulmonary hemorrhages within the past five or six months. He now has night-sweats and has lost considerable flesh. The temperature was 103.2° Fahr. The patient was too weak to leave the bed. Physical examination revealed cavities of considerable size at both apices. Tubercle bacilli were found in large number in the sputum. The patient was put on tonic treatment, a cough-mixture, creasote, three drops three times daily, and the usual inhalations.

July 20, 1888.—The patient was able to sit up. The temperature was normal, and the weight was one hundred and four pounds.

October 5.—The patient is now in a much better condition than at the time of his admission. He is able to be about the ward and his cough is less troublesome. The physical signs are about the same. Tubercle bacilli are present in the sputum, although in diminished quantity. The weight is one hundred and six pounds.

The number of cases of phthisis in Bellevue Hospital is never large, especially in the summer, as cases of chronic disease usually are sent to the Charity Hospital on Blackwell's Island; but even the few cases reported, although not long under observation, seem to me to be very instructive. These cases were unselected and the inhalations were employed in all the cases in the male wards, except those in the last stages of the disease and a few in which complications existed. Of the ten cases reported, four presented cavities and in six there was solidification only. All the cases were uncomplicated except one in which the right chest was half full of effusion, the liquid containing tubercle bacilli. The patients were all males of an average age of about twenty-eight years, the oldest being forty and the youngest nineteen. The average duration of treatment was forty-six days, the longest being ninety-nine and the shortest sixteen days. The average duration of the disease was a little more than six months, the longest being twelve months and the shortest between one and two months. In only two cases was there a fam-

ily history of phthisis. In two cases the temperature was normal. In one case the temperature was not recorded. In all the others there was more or less pyrexia, the temperature being 101° to 104° Fahr. Night-sweats existed in all the cases. There was a history of loss of weight in every case but one. Tubercle bacilli were found in eight cases. In two cases the sputum was not examined. In four cases there had been hemoptysis and in one of these this had occurred ten years before. The inhalations were well borne and gave relief to the cough in all the cases. In five cases the treatment was with creasote internally and inhalations. In five cases, in addition to this treatment, tonics, stimulants or expectorants were employed.

The results fairly attributable to the treatment by creasote internally and inhalations are the following:

WEIGHT.—The change in weight was one of the most important results observed. The gain, which occurred in every case but one, could hardly be attributed to changes in surroundings and diet, for the diet, though sufficient, probably was not more liberal than that to which the patients had been accustomed. The following table gives the changes in weight while the patients were under observation:

CASE.	Gain in weight.	Remarks.
I.	11½ pounds in 27 days.	Solidification at left apex; right chest half full of liquid.
II.	9 pounds in 28 days.	Small cavities at both apices.
III.	10 pounds in 28 days.	Solidification at right apex.
IV.	10 pounds in 16 days.	Solidification at right apex.
V.	20 pounds in 37 days.	After having gained 20 pounds, the patient had malarial fever and diarrhœa, and lost 14 pounds; he afterward gained 10 pounds in 62 days, making a net gain of 16 pounds in 99 days. Solidification at right apex.
VI.	6 pounds in 39 days.	Solidification at both apices, with cavity at right apex.
VII.	8½ pounds in 22 days.	Solidification at right apex.
VIII.	13 pounds in 49 days.	Solidification at both apices.
IX.	No change in weight.	Large cavities on both sides; general bronchitis; profuse expectoration; patient in bed and very weak.
X.	2 pounds in 15 days.	Large cavities on both sides; patient in bed and very weak.

Temperature.—In seven cases in which there was pyrexia when the treatment was begun, the temperature became normal within a very few days. In two cases (IV. and VII.) the temperature was normal when the patients were admitted. In Case IX. the temperature was not recorded.

Night-sweats.—All the patients had night-sweats. The night-sweats disappeared entirely in three cases (I., III. and V.); they were much diminished in six cases (II., IV., VI., VII., VIII. and X.); and in Case IX. the night-sweats were not affected. In Case IX. there were large cavities on both sides, with general bronchitis and profuse expectoration, and the patient was very weak.

Cough and Expectoration.—In three cases (I., III. and V.) the cough and expectoration nearly or quite disappeared. In all the cases there was improvement, which was generally quite marked. There was slight improvement even in Cases IX. and X., in which there were large cavities. There was considerable improvement in Cases II. and VI., in which there were small cavities.

Physical Signs.—The physical signs showed more or less improvement in all the cases, except in Cases II., IX., and X., in which there were large cavities. In Case X. the bacilli in the sputum were diminished. In the remaining cases no examinations for bacilli were made after the treatment was begun.

General Phvsical Condition.—In Cases I., III. and V. the patients said they were perfectly well. In Case I. there was solidification at the left apex and the right chest was half full of liquid. In Cases III. and V. there were signs of solidification at one apex. Tubercle bacilli were present in the sputum in all these cases.

The appetite was improved in all the cases recorded. In all the cases, also, there was improvement in strength. In Cases IX. and X., with large cavities, the patients were in bed and very weak at the beginning of the treatment, but afterward were able to be up and about the ward.

Cases with Solidification only.—In the six cases in which there were no cavities the improvement under treatment was very marked. In three cases (I., III. and V.) the strength and weight were regained, all the symptoms disappeared and the patients expressed themselves

as feeling perfectly well. These patients were under treatment for twenty-seven, twenty-eight and thirty-seven days respectively.

The gain in weight was considerable in all six cases. The smallest gain was in Case VII., eight pounds and a half in twenty-two days, and the largest was in Case V., twenty pounds in thirty-seven days. In the four remaining cases the gain in weight was between ten and thirteen pounds. In all six cases it was recorded that the symptoms were much improved.

Cases with Cavities.—In Cases IX. and X. there was but little improvement. In these cases the cavities were large.

In Case II., in which there were cavities of moderate size at both apices, with a loss of weight of twenty-five pounds in six months, under treatment there was a gain of nine pounds in twenty-eight days, the temperature was reduced from 104° Fahr. to normal, there was diminished cough, expectoration and night-sweats and the strength and appetite were improved.

In Case VI. hemoptysis had occurred ten years before, there had been "considerable" loss of weight, the temperature was 101° Fahr., and there was a cavity at the right apex. Under treatment there was a gain in weight of six pounds in thirty-nine days, the temperature became normal and the cough, expectoration, night-sweats, etc. were improved.

CONCLUSIONS

The records of the ten cases reported show that creasote by the stomach and the inhalations, in cases of solidification without cavities, effect prompt and decided improvement in all phthisical symptoms, with increase in appetite, weight and strength, even with surroundings much less favorable than would obtain in many cases in private practice.

In cases with small cavities much less improvement is to be looked for, but some benefit may be expected.

In cases with large cavities the treatment seemed to have little more than a palliative influence.

The observations here recorded are defective as regards the influence of the treatment upon the bacilli. In

one case, with large cavities, it was noted that the number of bacilli was diminished. No other examinations for bacilli were made during or after treatment.

No estimate was made of the relative value of creasote taken into the stomach. As regards the inhalations, it is assumed that the chief benefit was derived from the creasote, the spirits of chloroform and the alcohol rendering this agent more volatile and soothing the mucous surfaces. The inhaled vapor undoubtedly penetrated by diffusion as far as the air-cells. It is by diffusion that fresh air, anesthetic vapors, etc., penetrate the lungs, and cases of pneumonokoniosis illustrate the fact that even solid particles may be carried to the pulmonary vesicles.

I have employed the method of inhalation here described, conjoined with other treatment, in private practice, with good results. In a case of irritative cough of several months' standing, with slight bronchitis and emphysema but no signs of phthisis, which resisted ordinary treatment, three inhalations produced complete relief, and the cough had not reappeared at the end of four weeks.

XXXII

A CASE OF SCIATICA TREATED WITH LARGE DOSES OF ANTIFEBRIN

Published in "The Medical Record," New York, for December 1, 1888.

M. G——, aged twenty-five, laborer, was admitted to Ward 19, Bellevue Hospital, August 14, 1888. The family history was negative. As regards the previous history there is nothing special to note until about a year ago, when the patient had pain, with soreness and tenderness, at the back of the right thigh, extending as far as the knee. This became so severe that he was compelled to keep the bed for two or three weeks. Under treatment at that time he improved but has not been entirely free from pain since.

For the past three weeks the pain has been so severe that the patient has been confined to the bed most of the time. He has been treated with blisters, iodine and a variety of internal remedies. Electricity had been tried before his admission into the hospital but this gave no relief.

August 16, 1888.—The right leg was buried in flowers of sulphur for thirty-six hours. The patient said the pain was "perhaps a little better" after this application.

August 18.—Sulphur was again applied for forty-eight hours but without relief. At the end of that time the urine had a distinct odor of hydrogen monosulphide.

August 25.—The patient was brought under the influence of ether and the nerve was stretched by forced flexion of the thigh. This gave no relief.

August 26.—I requested Dr. Maury, the house-physician, to administer antifebrin in as large doses as could be borne, watching the patient carefully. This treatment was carried out even more heroically than I had expected. At 11 A. M. Dr. Maury gave twenty grains of antifebrin; at 1 P. M., fifteen grains, and at 3 P. M., fifteen grains, making in all fifty grains within four hours. The patient became somewhat cyanotic and a half-ounce of whisky was given with the last dose.

August 27.—The pain was nearly but not entirely relieved, and the antifebrin was given again in the following doses: 10 A. M., twenty grains; 12 M., twenty grains, making forty grains within two hours. It was not necessary to give whisky.

August 28.—The pain was entirely relieved and the patient walked about the ward without difficulty. The large doses of antifebrin taken on August 26th and 27th had no unpleasant effects,

and the patient expressed himself as feeling perfectly well, absolutely free from pain and able to move about as he did a year ago before he was first attacked.

August 31.—The patient was discharged. He insisted on leaving the hospital to go to work. He promised, however, to report himself in case the pain should return. At the date of writing (November 12, 1888) no report from the patient has been received.

The treatment with flowers of sulphur was tried in accordance with a suggestion quoted from Guéneau de Mussey, in the "Therapeutic Gazette," April 16, 1888, page 276. This suggestion was followed out efficiently. The parts were covered with flowers of sulphur spread on a cloth, and the characteristic odor of hydrogen monosulphide was recognized in the urine after the second application.

Guéneau de Mussey recommended that the application be continued for twenty-four hours. I have since learned that this treatment had already been tried in the hospital without satisfactory results.

In the treatment that was finally successful I intended to push the antifebrin to the extreme limit of safety, which apparently was done, and certainly, in this case, with entirely satisfactory results; although it was thought necessary to administer these large doses carefully and to watch the patient very closely.

XXXIII

A TONIC FORMULA

Published in the "New York Medical Journal" for May 18, 1889.

In the "New York Medical Journal" for July 31, 1886, Prof. Allard Memminger, of Charleston, S. C., published a short article on "Bright's Disease of the Kidneys successfully treated with Chloride of Sodium." The salt is given in doses of ten grains three times daily, the doses being increased by ten grains each day until they amount to fifty grains each. It is then diminished to sixty grains in the day and continued. I employed this treatment in a few cases but did not meet with the success noted in four cases reported by Professor Memminger, although in some instances there was considerable improvement. The suggestion by Professor Memminger, however, and his theory of the mode of action of the sodium chloride, pointed to a possible deficiency in certain cases of disease in the saline constituents of the blood. With this idea I prepared a formula in which most of the important inorganic salts of the blood are represented, with an excess of sodium chloride and a small quantity of reduced iron, the various salts, except the sodium chloride, being in about the relative proportion in which they exist in the normal circulating fluid. I first used this preparation in the form of powder, giving ten grains three times daily after eating. It was afterward put up in gelatin capsules, each containing five grains, but these absorbed moisture so that they would not keep well in warm and damp weather. I finally modified the formula, however, so as to avoid this difficulty. The preparation is now in the form of compressed tablets under the name of "saline and chalybeate tonic." I usually prescribe two tablets three times daily after eating. In a few cases six tablets daily have produced some "fullness" of the head, when I have reduced the dose to one tablet three times daily.

The following is the formula that I finally adopted:

SALINE AND CHALYBEATE TONIC

℞ Sodii chloridi (C. P.)	ℨ iij
Potassii chloridi (C. P.)	gr. ix
Potassii sulph. (C. P.)	gr. vj
Potassii carb. (Squibb)	gr. iij
Sodii carb. (C. P.)	gr. xxxvj
Magnes. carb	gr. iij
Calc. phos. præcip	ℨ ss
Calc. carb	gr. iij
Ferri redacti (Merck)	gr. xxvij
Ferri carb	gr. iij

M. In capsules, No. 60.
Sig.: Two capsules three times daily after eating.

I first used this tonic in a case of simple anemia in Bellevue Hospital in July, 1887. In this case the anemia was profound and the pallor excessive. It had existed for several weeks; there was loss of appetite, and the patient, a female about thirty years of age, was very feeble and unable to leave the bed. A powder of ten grains was given three times daily, and this, with good diet, constituted the only treatment. In forty-eight hours the patient was sitting up, with a fair appetite and improved in appearance, notably in color. At my next visit, two days later, she had left the hospital greatly improved.

Since the summer of 1887 I have given the tonic in nearly every case in private practice in which a chalybeate was indicated. In many cases I have not been able to watch the effects of the remedy, and in many I kept no records. In thirty-three cases that I have noted as cases of anemia, with loss of appetite, etc., I have more or less complete records. In twenty-two cases I noted very great improvement, in twelve cases improvement not so well marked and in one case no improvement.

I also have records of five cases of chronic Bright's disease of the kidneys in adults in which the tonic was the only medicinal remedy employed. The following is a brief report of these cases:

CASE I.—Male, intemperate, height five feet seven inches, weight in health two hundred and sixteen pounds, age twenty-eight. He had lost about sixty pounds in weight within nine months, weighing now one hundred and fifty-five pounds. The urine had a specific gravity of 1012 to 1015 and was loaded with albumin. There were granular casts in abundance. He was put

upon the "tonic," ten grains three times daily, and told to stop drinking. After about six weeks of "moderate" drinking, but constant use of the tonic, he had greatly improved. He then began drinking heavily and stopped the tonic. About a week after this the urine had a specific gravity of 1021, there was a very small quantity of albumin, but no casts. He then resumed the tonic and drank less. In three days he was much improved. The urine had a specific gravity of 1024, with a faint trace of albumin but no casts. I saw the patient about five months after the beginning of treatment. He had been taking the tonic regularly for the past three months, but had frequently drunk to excess. He was, however, much improved and had gained seven pounds in weight. His urine had a specific gravity of 1022, with no albumin (or the faintest trace) but no casts. About ten weeks after this he had been drinking heavily and had a mild attack of delirium tremens. His urine had a specific gravity of 1010½ with six grains and a half of urea to the ounce. There was no albumin and there were no casts. Under treatment for alcoholism he improved rapidly and was out in three days. Within the last year I have seen the patient casually from time to time, but have not had an opportunity of examining the urine. He looks well and says he is in perfect health, but he still drinks, and sometimes to great excess.

Case II.—This patient was about fifty years of age, looking in fair health, whose urine I examined in September, 1886, and found a trace of albumin. In February, 1888 I examined the urine and found a specific gravity of 1012 and a considerable quantity of albumin, but no casts. I then ascertained that for several months he had drunk about a bottle of whisky daily. He was directed to stop drinking and take of the tonic two capsules three times daily. Three weeks after he had taken the tonic regularly the urine was normal and had a specific gravity of 1024. I had reason to think that the patient continued to drink to excess, but I could not keep the case under observation.

Case III.—The patient was a widow thirty-eight years of age. About six weeks before she came under observation she noticed that her sight was failing; she could not distinguish faces and did not go alone in the streets. The urine was abundant, with a specific gravity of 1011½ and a small quantity of albumin. She had lost considerable flesh within the past two months. There was a mitral systolic and an aortic diastolic murmur, but no enlargement of the heart. There was slight œdema of the feet. She was put on the use of the tonic, two capsules three times daily. In a week I saw her again. There was no marked change. She complained of want of sleep and was directed to take five grains of acetanilid at night and to reduce the tonic to one capsule three times daily. She left the city and went to a village in Ontario for the summer. In January, 1889, eight months after, she wrote for a renewal of the tonic prescription and said she had been perfectly well until within a few days, but gave no details.

Case IV.—A clergyman, fifty years of age, of temperate and regular habits, had become "run down" from overwork and had

lost twenty-three pounds in weight within seven or eight months. Within a few weeks albumin had been discovered in the urine. On physical examination I found nothing abnormal except the urine and a reduplication of the first sound of the heart. The urine had a specific gravity of 1022, with albumin in considerable quantity and a few hyaline casts of medium size. He was put on the use of the tonic, two sugar-coated tablets three times daily after eating. He went to Bermuda, January 20, 1889. On April 1, 1889 he returned from Bermuda, feeling "perfectly well." He brought a report of a number of examinations of his urine, which showed a small quantity of albumin and no casts. On April 1st the urine had a specific gravity of 1021, with a moderate quantity of albumin. He had taken the tonic regularly since January 29th.

Case V.—A widow, fifty-nine years of age, about ten years ago began to lose weight rapidly. Since that time she had lost about twenty pounds. About five years ago she noticed a considerable increase in the quantity of urine, with excessive thirst. The history was that of dietetic diabetes, but the disease was recognized only a few days before she came under my care. The urine had a specific gravity of 1016½, with a large quantity of albumin and six grains and a half of sugar to the ounce. There were no casts and the quantity of urea was four grains to the ounce. There was slight œdema of the feet.

Under a strict antidiabetic diet for two days the sugar disappeared from the urine, the specific gravity was 1013 and the quantity of albumin was slightly diminished. The quantity of urea was six grains to the ounce. The œdema had disappeared. She was then put on the use of the tonic, one capsule three times daily.

Four days after, the tonic was increased to two capsules three times daily and the patient was allowed to have a little bread. The urine contained no sugar but the quantity of albumin was unchanged.

Nine days after she came under treatment the urine had a specific gravity of 1015½, with a faint trace of sugar, and the quantity of urea was six grains and three quarters to the ounce. The quantity of albumin was very much diminished.

Two days after, the quantity of urine was normal, specific gravity 1012½, urea six grains and a half to the ounce, albumin in small quantity, a trace of sugar, no casts.

The general diabetic symptoms disappeared on the second day of treatment.

These five cases of albuminuria are reported with reference only to the effects of the "saline and chalybeate tonic." In all the cases the tonic seemed to exert an influence on the quantity of albumin in the urine, which was specially marked in Case I.

In the great majority of the cases of anemia, etc., in

which iron was strongly indicated, the tonic seemed to act much more promptly and favorably than the chalybeates usually employed. In a certain number of cases in which patients stated that "they could not take iron in any form" the tonic produced no unpleasant effects.

XXXIV

SOME MEDICO-LEGAL POINTS IN THE "FRENCHY" MURDER TRIAL

Published in the "New York Medical Journal" for July 11, 1891.

In this short article I shall give only certain points in the medico-legal history of the trial, with the development of which I was specially connected. A complete history of the trial will undoubtedly be published eventually at the proper time and in the usual way; and it is probable that Dr. Edson and Dr. Formad, with whom I was associated in behalf of the people, will give some account of their own individual connection with the case. The trial was certainly remarkable, not only on account of certain novel medico-legal points, but from the extraordinary nature of the crime, the unusual character of the criminal, certain points of similarity to the murders committed by "Jack, the Ripper," and the possibility (very remote, it is true) that the murderer may be "Jack, the Ripper" himself. It is not pretended that the short history which I shall give of the crime will be exactly accurate, as the details are not taken from official records; but the account is substantially correct and sufficiently minute for the purposes of this article.

The prisoner was indicted under the name of George Frank. He was known also as "Frenchy." His real name was said to be Ameer Ben Ali. He was born in Beni Aisha, a village in the valley between Algiers and Belida. He said that he did not know his age, but he appeared to be between thirty and forty. He was said to have served in the French army in a regiment of Turkos for eight years. He could not be made to state exactly when he came to this country or to the city of New York.

Shortly after midnight on the night of April 23–24, 1891 Carrie Brown, known as "Shakespeare," an abandoned woman of dissolute and intemperate habits, fifty-

five years of age, came to a low resort known as the East River Hotel, in the city of New York, and went to Room No. 31 with a man who was not the prisoner. This man disappeared during the night and has not been found up to the present time. In the hotel are several rooms on either side of a hall.

The prisoner came to the hotel alone about 1 A. M. of the same night. He went with a candle to Room 33, across the hall from Room 31. About 5 A. M. on April 24 the prisoner was seen to leave the hotel. About 10 A. M. April 24 the body of the murdered woman was found on the bed in Room 31. A small red shawl and a petticoat, both blood-stained, were wound around the head. The lower part of the abdomen was slashed open and several inches of the lower part of the ileum were cut out completely and left in or near the body. Other parts of the ileum were cut open and one ovary was pulled out. The stomach and large intestine were not injured. An ordinary case-knife, broken and sharpened to a point and stained with blood, was found near the body. The bed-ticking under the body was soaked with blood. Three or four spots of blood were found in the hall, between Room 31 and Room 33. A spot of blood as large as a dollar was found on the bed and a spot of about the same size on a wooden chair in Room 33. Bloody finger-marks were found by the side of the door of Room 33 and on the wall near the door.

It was in evidence that the murdered woman had said to a female acquaintance on the afternoon of April 23 that she had eaten nothing for several days. On that afternoon she took a glass of beer and a cheese-sandwich and some corned beef, raw cabbage and pickle from a "free-lunch" counter.

It was in evidence that the prisoner had been in the habit of going to the hotel with women, and had frequently left his room, tried the doors of other rooms and sometimes had gone into other rooms and remained awhile.

Dr. W. T. Jenkins, deputy coroner, testified that the murdered woman had died of strangulation. He also testified to the condition of the abdomen and its contents, which has already been described.

The prisoner was arrested the night after the murder.

His shirt and both socks were stained with blood. The largest stain on the shirt was on the front flap. There were smaller stains on the right sleeve, the left sleeve and the back. Four days after the arrest matters were taken from beneath the finger-nails of the prisoner. The nails were unusually long.

In general terms, the theory of the prosecution was that the prisoner had taken Room 33 for the purpose of entering other rooms during the night and gratifying his passions with women whom he might find alone; that he had entered Room 31 at some time during the night and had found Carrie Brown after her male companion had left her; that in some way he had become enraged at the woman, had taken her by the throat and strangled her; that the mutilation, etc., were evidences of a certain ferocity of temperament not to be wondered at in a person of his character and previous record; and that after having murdered the woman he had returned to Room 33, and had left the hotel as soon as practicable, without attracting particular attention, in the morning. The prosecution maintained that the blood-stains nearly all contained, mixed with the blood, contents of the lower part of the ileum.

The theory of the defense was that the woman was killed by the man who went with her to Room 31 and disappeared during the night; that it could not be shown that the stains on the prisoner's person and clothing were blood mixed with the contents of the small intestine; and that the blood on the prisoner's shirt was from a woman with whom the prisoner had had connection the night before the murder, during her menstrual period.

The trial began on June 29 and a verdict of guilty of murder in the second degree was rendered on the evening of July 3, 1891.

The verdict was reached on circumstantial evidence alone. Stripping the case of all minor considerations and circumstances which may have influenced some of the jurors more or less, the evidence which convicted the prisoner was that the various specimens examined by the experts for the people presented blood mixed with matters which must have come from the small intestine, and which, by no reasonable theory, could be on the prisoner's cloth-

ing and person unless they came from the body of the murdered woman. It is this point in the case which, so far as I know, is without precedent and is of peculiar medico-legal interest.

Dr. Cyrus Edson made examinations of the specimens and testified before the coroner's jury. On June 20, 1891 Dr. Henry F. Formad, of the University of Pennsylvania, was associated with Dr. Edson in the investigations. On June 26 I was associated with Dr. Edson and Dr. Formad.

I found, on June 26, that Dr. Edson and Dr. Formad had made microscopical preparations as follows: *a*, matters taken from beneath the free edges of the finger-nails of the prisoner; *b*, from the front flap of the shirt; *c*, from the right sleeve of the shirt; *d*, from the back of the shirt; *e*, from the left sleeve of the shirt; *f*, from another piece of the left sleeve of the shirt; *g*, from the wall-paper on the hall near the door of Room 33; *h*, from wood taken from the outside of the door of Room 33; *i*, from the floor of Room 33; *j*, from the socks of the prisoner; *k*, from the door-casing of Room 33; *l*, from the wooden chair in Room 33; *m*, from the floor of the hall, between Room 31 and Room 33; *n*, from the bed-ticking in Room 33; *o*, from the knife found in Room 31; *p*, from the door of Room 33; *q*, from the bedticking under the murdered woman in Room 31; *r*, from the stockings of the murdered woman; *s*, from the petticoat tied around the head of the murdered woman; *t*, from the sheet on the bed in Room 31.

In all of these specimens mammalian blood was found, presumably human blood.

In *d*, *e*, *f*, *m*, *n*, *r* and *s*; viz., back of prisoner's shirt, left sleeve of shirt, the second piece of left sleeve, floor of hall, bedticking from Room 33, stocking of murdered woman, petticoat tied around the head of the murdered woman, nothing but blood was found. In all the other specimens; viz., matters under prisoner's nails, front flap and right sleeve of shirt, wall-paper from hall, wood from door, casing of door, chair, socks of prisoner, knife found in Room 31, bedticking and sheet from Room 31, blood was found with more or less admixture of the following: 1, biliary coloring matter unchanged; 2, fat globules and crystals; 3, tyrosin; 4, cholesterin; 5, triple phosphates; 6, columnar epithelium; 7, eggs of round worms; 8, starch

granules; 9, partially digested muscular tissue, with a few fibres perfect, and partially digested vegetable matters; 10, "molecular detritus."

Dr. Formad testified to the appearances as stated above and his testimony was confirmed by Dr. Edson. I examined certain of the specimens, to be enumerated hereafter, with special care, and confirmed the testimony of Dr. Formad.

With this introduction, I shall now describe my own observations and conclusions in this remarkable case:

On June 26 I was invited to join Dr. Edson and Dr. Formad and made with them an examination of the specimens. The specimens that I examined with special care were those from the bedticking from under the murdered woman, the matters from the finger-nails, from the front flap and right sleeve of the prisoner's shirt and from the prisoner's socks. In all of these specimens I discovered essentially what was observed by Dr. Edson and Dr. Formad. In addition to the blood, the matters that were particularly prominent were sheaves of crystals of tyrosin, columnar epithelium brightly colored with bile, partially digested muscular tissue and a very few muscular fibres nearly perfect in their structure, with the hard residue of spiral and other vegetable cells. In addition I observed a number of microörganisms such as are found both in the large and the small intestine. On inquiring in regard to the part of the intestinal tract that had been opened, I was informed that it was the large intestine; but the records of the post-mortem examination were not in the hands of my associates. Notwithstanding this statement and the general impression that the specimens represented blood mixed with feces, I formed and expressed to Dr. Edson and Dr. Formad the decided opinion that the blood was mixed with the contents of the lower part of the ileum. My grounds for this opinion were the presence of tyrosin and bilirubin, which do not exist in the normal feces, and incidentally the presence of a few very slightly altered muscular fibres, such as probably would not be found in the large intestine. After reëxamination of the specimens and consultation, we all agreed that the matters mixed with the blood came from the small intestine; and a record of the autopsy, received later, showed that a portion of

the lower part of the ileum had been cut out, the large intestine being uninjured. I emphasize this point for the reason that the case turned on the distinction between the contents of the ileum and the feces. Whatever credit may be attached to the originating of this theory must carry with it a very large share of the responsibility of the conviction of the prisoner; for it was the general opinion, at least of those connected with the prosecution, that this was the fatal point against the prisoner, as feces, especially in persons of filthy habits, might have been derived from sources other than those alleged by the people.

On the witness-stand I testified substantially to the following facts and conclusions:

1. That the specimens examined by me contained tyrosin, bilirubin, columnar epithelium, partially digested muscular tissue and vegetable substances, microörganisms, etc.

2. That the tyrosin and bilirubin must have come from the small intestine, while the other substances might exist in the large intestine.

3. That tyrosin is formed by the prolonged action of the pancreatic juice upon proteids, these matters being first converted into trypsin-peptones and afterward into tyrosin, the change into tyrosin being aided by the action of intestinal microörganisms.

4. That the bilirubin, which strongly colored the epithelial cells and the molecular matters, was characteristic of the contents of the small intestine.

5. That the appearances were practically the same in all the specimens.

My opinion that the matters were from the small intestine was based mainly on the presence of tyrosin and bilirubin.

I further testified that after matters pass from the small into the large intestine, tyrosin ($C_9H_{11}NO_3$) is changed into indol (C_8H_7N), and that bilirubin ($C_{32}H_{36}N_4O_8$) is changed into hydrobilirubin or stercobilin ($C_{32}H_{40}N_4O_7$) and becomes of a brown color; that the recognized matters peculiar to the feces are indol, skatol (to which the peculiar odorous matters adhere), phenol, stercorin, excretin and excretoleic acid.

Judging from the verdict, the jury believed that the

blood was mixed with the contents of the small intestine and not with feces; and also that the matters found on the prisoner's person and clothing were identical with those found on the ticking of the bed on which the murdered woman lay.

While under examination on the witness-stand I could of course do nothing more than give answers to the questions asked. Here, however, I may enter into some discussion of the opinions expressed.

The changes which result in the formation of tyrosin in the small intestine, and its further change in the large intestine, are well recognized by physiologists. Tyrosin is found in health in other parts, such as the substance of the spleen, pancreas and liver. In certain diseased conditions it may be found in other situations. In perfectly normal digestion tyrosin is by no means constant in the small intestine; but it is seldom found in the feces, and then only in some kinds of diarrhea and in cholera.

Bilirubin (the unchanged coloring matter of the bile) is always found in the small intestine if bile is discharged into the duodenum. It does not exist in the feces, and stercobilin, which is brown in color, will not respond to the ordinary color-tests for bilirubin. The exceptions are only in pathological conditions, especially when the feces are of a green color.

Relying on the presence of tyrosin and bilirubin, taken in connection with the fact that the small intestine was cut and the large intestine was uninjured and that there was no part injured that could have furnished tyrosin, the conclusion to my mind was inevitable that the matters mixed with the blood, in the specimens which I examined, were practically identical and that they came from the ileum.*

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* The last article in this collection is entitled "Reminiscences of the 'Frenchy' Murder Trial." It is partly a repetition of this article and was written because of the release of "Frenchy" in 1902.

XXXV

REMARKS ON FERMENTATIVE DYSPEPSIA *

Published in the "New York Medical Journal" for October 14, 1893.

THERE are few diseases that present greater difficulties in the way of treatment and of permanent cure than what may be termed functional dyspepsia. In using the term functional dyspepsia I wish to be understood as meaning difficulty in digestion unconnected with ascertainable lesions of the digestive organs or of the alimentary tract, and not complicated with serious organic disease of other parts. While certain alterations may exist in the digestive organs, they are temporary, at least when the disease is not of long standing, and they must disappear in cases of permanent relief. Almost all cases of dyspepsia of long standing are accompanied with more or less mental and moral disturbance, even though the periods of pain or discomfort may not be very long. These nervous symptoms I do not propose to describe. They are protean in their character and manifestations and are often relieved or mitigated by moral influences, such as change of scene or occupation, without much actual improvement in digestion. They almost invariably disappear as the normal digestive processes are restored. The long-standing "peripatetic" cases, with which physicians are unhappily too familiar, have been prominent among the unsatisfactory and discouraging experiences in general practice. Such cases frequently are treated with but little expectation of permanent relief; and the most satisfactory result usually to be expected has been temporary improvement by means of palliatives, and a life rendered more or less miserable by a real or fancied necessity of constant attention to diet and general hygiene. It is in precisely such cases as these (unconnected with gross excesses or indiscretions

* Read before the New York State Medical Association, October 12, 1893.

in diet, and especially with the abuse of alcoholic beverages or of narcotics) that modern medicinal therapeutics seems likely to produce such results as will render the treatment of fermentative dyspepsia of a purely functional character almost as certain and satisfactory as that of any acute trivial disorder.

Flatulence is a very common attendant of functional dyspepsia. This condition may be more or less pronounced and there are great variations in the degree to which it is tolerated by different individuals. The discomfort and distress which accompany flatulence may amount to actual pain, which is sometimes, though rarely, intense; but when pain is habitual, remedies directed to its prompt relief are merely palliative and usually do harm in the end. This remark is specially applicable to all forms of opiates, whether administered by the mouth or by subcutaneous injection. Contrary to the popular and, to a certain extent, the professional notion, I must apply this remark as well to the various pepsins, pancreatins "et id genus omne," so commonly prescribed. I have fairly full records and histories of a score or more of what may be called peripatetic cases of dyspepsia of several years' standing which have been subjected to nearly every variety of routine treatment, and these constitute but a small part of the cases that have come under my observation. I have yet to see, however, a case in which any of the pepsins, pancreatins or the physiologically absurd combinations of pepsin and pancreatin logically seemed to have produced any benefit, even of a temporary character. In certain cases in which they have appeared to act favorably as palliatives, careful inquiry has almost invariably shown an attention to diet and hygiene during their administration to which their apparently favorable effects have been fairly attributable. If this statement is even in a measure correct, it is important that the fact should be recognized and appreciated, in view of the gratuitous instruction in the physiology of digestion and the pathology and therapeutics of dyspepsia offered so freely to physicians in the advertising pages of medical journals and in circulars by pharmaceutical manufacturers and even meat-packers, and indiscreetly indorsed by members of the profession. Of late years my opinions have not permitted me to ex-

tend my experience in pepsins, etc.; but the histories of previous treatment in cases that have come under my observation, as well as physiological considerations, have convinced me that agents intended to supply an assumed deficiency of digestive enzymes are inert. I do not wish, however, to be understood as including in this condemnation the use of foods partially digested, or peptonized, undoubtedly valuable in many cases.

This subject to my mind is so important that it seems proper to give my reasons for the decided opinion just expressed:

Digestion is one of the most complex of the physiological processes; and even now it is but imperfectly understood. Concerning certain facts, however, there can be no doubt. It is well known to physiologists that a combined as well as a successive action of the digestive fluids is essential to normal digestion. If the food is imperfectly masticated and insalivated, especially the latter, digestion becomes difficult. It is essential, not only that the saliva should exert its own chemical and mechanical action, but that it should become gradually mixed with the secretions of the stomach, and that the gastric juice should as gradually be mixed with the food, the pepsinogen being transformed as it is discharged from the peptic cells into pepsin by the action of the hydrochloric acid produced by its peculiar cells. Assuming, even, that a few grains of what is called pepsin, extracted from a pig's stomach and dried, will have the same action in the human stomach that it has on minced food in a test tube, it is by no means certain that the discomfort and distress sometimes observed soon after taking food are due to deficiency of pepsin. As a rule these symptoms are produced by the undue formation of gases, which artificial pepsin is not known to have any power to control. Normally the gases of the stomach do not exist in large quantity and probably are derived mainly from the air which is incorporated with the food in mastication; an evidence of which is the presence of a considerable proportion of oxygen, which is not found in other portions of the alimentary tract. When gas is formed in the stomach, it probably is due to the action of microörganisms which take no part in digestion.

It is almost inconceivable that artificially extracted

digestive enzymes can find their way into the small intestine in such a condition as to exert any action in digestion. The so-called pancreatin has no existence, the enzymes produced by the pancreas being trypsin, amylopsin and steapsin. Intestinal digestion, also, is an alkaline process; and it has been shown by experiment that it can not go on with sufficient efficiency to support life in the absence of the action of the intestinal juice, the composition of which is unknown, and of the bile, the action of which has never been clearly understood and defined. Life, indeed, can not be maintained in the absence of either the bile or the intestinal juice.

Gases are much more abundant in the small intestine than in the stomach; and a certain quantity of gas is essential to the proper movements of the alimentary mass under intestinal peristaltic action. The composition of the gas in the small intestine (consisting, as it does, of carbon dioxide, pure hydrogen, and nitrogen in variable proportions) shows that it is in greatest part derived from the food, even if it is admitted that a certain proportion of the carbon dioxide may be evolved from the blood. When gases are produced in excessive quantity in the small intestine, the action of microörganisms probably is involved. It is not pretended that the so-called pancreatin has any influence in modifying or restraining this action.

In cases of functional dyspepsia it is by no means invariable that the body is badly nourished, unless the diet is greatly restricted. Many dyspeptics have an appearance of perfect health. While digestion may be slow, labored and attended with great discomfort and even actual pain, the processes may be efficient and complete, and general nutrition may be perfect. Although such cases are exceptional they are not uncommon. It is seldom observed, however, that a strict diet called, perhaps, antidyspeptic secures immunity against dyspepsia; although it is desirable and useful to avoid notoriously indigestible articles and those which, in individual cases, have been found to occasion distress.

In my opinion it is seldom the case that undue fermentation in the alimentary mass begins in the intestinal canal. It usually occurs first in the stomach and is con-

tinued in the small intestine. In the exceptional cases in which its origin is intestinal there usually is a deficiency of bile, and more or less active diarrhea is present. In the great majority of cases, however, constipation is fully as common as diarrhea, and sometimes the bowels are regular. When there is no gastric flatulence, when the digestive discomfort begins two or three hours after the taking of food and when diarrhea with flatus is present, it is probable that the fermentation is purely intestinal and that it continues in an abnormal degree after the residue of food has passed into the large intestine. In all cases it is important to regulate the action of the bowels, either by laxatives or by agents that have the opposite effect. I have been lately in the habit of using Villacabras water as a laxative when constipation is obstinate. By carefully regulating the dose of this water according to the effects observed in individual cases, I have found it to act most satisfactorily. Using it for any considerable time, the dose, as well as the frequency of its administration, may be diminished rather than increased; and the dejections usually are easy and painless. I give before breakfast enough to produce two or three evacuations; and for two or three days after, a daily movement follows. It may then be repeated if necessary and given as required. A very important point in the treatment of dyspepsia with constipation is to see that the patient acquires the habit of soliciting, without great effort, a movement of the bowels every morning at a fixed hour, resisting a desire for defecation at other times. Attention to this will sometimes regulate the bowels without the use of laxatives. In cases of undue looseness of the bowels, the remedies administered with the object of restricting fermentation will often suffice. Opium or its derivatives should never be used unless imperatively demanded by intense pain.

My main object in writing this paper is to call attention to the value of certain modern additions to the materia medica that act as antifermentatives. For many years the late Dr. Austin Flint was in the habit of using salicin in doses of about ten grains before each meal, often with remarkable success. I have used this remedy very largely and have frequently found it of great benefit; but

I have lately employed other agents which seem to be much more efficient.

In nearly every case of functional dyspepsia that has come under my observation within the last ten months I have begun treatment by giving five grains of bismuth subgallate, either before or after each meal. In some cases it seems to act more favorably when given before meals, and in others its action is better if taken after eating. In studying my records and memoranda of cases, I find that the treatment by salicin has often been unsatisfactory. The proportion of unsuccessful cases was about twenty-five per cent.; but in some cases the effects of this remedy given alone have been remarkable. I have full records of one case of severe dyspepsia of ten years' standing that was completely relieved in a week, without any return, now for more than a year. Bismuth subgallate, however, is almost a specific in cases of purely functional dyspepsia with flatulence. While I have full records of a few obstinate cases, the histories of most are merely short memoranda, and of many I have no records. Since December 8, 1892, when I began to use bismuth subgallate, I have noted only two cases in which it gave no relief, there being no evidence of organic disease. Both of these were in hysterical women. In both I used salicin and salol; and in one, salol, salicin, naphthalin and aristol. These were cases of long standing, that had resisted treatment of every kind, and they soon passed from under my observation.

I was led to use bismuth subgallate by seeing it recommended as a valuable remedy in the diarrhea of children, acting as a disinfectant. I first employed it in a case of dyspepsia of eleven years' standing which is so remarkable in some of its characters that I shall give farther on an account of it somewhat in detail. Its action in this case was so favorable that I began to prescribe it very largely, almost invariably with remarkably satisfactory results, and I continue to use it almost daily. I have no records of many of my cases, but have been careful to note the few instances in which I have been disappointed in its effects, with certain cases in which its favorable action has been truly remarkable. I have already mentioned the two cases in which it seemed to be of no benefit. The following are

a few of the cases of remarkably prompt and favorable action: A case of alcoholism of twenty years' standing, with habitual dyspepsia for the past five or six years; bismuth subgallate gave almost instant relief; the flatulence and distress disappeared in twenty-four hours, and did not return, except in a very mild degree, when they usually were relieved by a single dose. While under other treatment for alcoholism this condition was relieved. The patient has taken no alcohol for several weeks and has no craving for it. A case of dyspepsia of four years' standing, with a chronic diarrhea, was entirely relieved in five days by the use of the bismuth subgallate alone. A case of dyspepsia of more than thirty years' standing was promptly relieved by bismuth subgallate alone. In this case, every few weeks the trouble returns and is relieved by two or three doses. I am, indeed, no longer surprised at results from the use of this remedy which first seemed to me remarkable; and now I confidently expect prompt and favorable action. I have been in the habit of prescribing it in capsules containing five grains each, but lately have had it prepared in the form of tablets. In this latter form it is more convenient and seems to act more favorably.

The following case, which I give on account of certain remarkable and interesting features, is the first in which I used bismuth subgallate:

On November 16, 1892 a gentleman, about forty years of age, tall and robust, with the appearance of perfect health, consulted me in regard to a long-standing dyspepsia. He had suffered from indigestion with considerable pain for a long time, and about eleven years ago, under the advice of a physician, had adopted an exclusively milk diet. Since that time he has taken milk and nothing else, consuming about five quarts in twenty-four hours. He has been in the habit of taking milk about every half hour during the day and at variable intervals at night. If he goes more than an hour during the day without milk, he has gastric and intestinal pain which becomes almost unbearable but is soon relieved by about half a pint. With the pain he has great flatulence and violent eructations. During the past eleven years he has engaged in literary work and has travelled extensively in this country and abroad. While taking milk, however, he has felt well, slept well, taken considerable exercise and his bowels have been regular. His personal and family history is good in every respect, and a careful physical examination failed to reveal structural disease of any organ. He wished to be treated for what he called the "milk habit."

I directed him to cut off milk promptly and absolutely, and to take three meals a day without restriction as to quantity or kind of food, except that he was to avoid sweets and pastry and be moderate in the use of wine at dinner. I prescribed ten grains of salicin four or five times daily, and always to take a dose after eating. On the evening of the first day of treatment he went to a dinner party, eating and drinking of everything. He described his sensations at the dinner as most delightful, enjoying his unaccustomed food immensely; but his teeth were sore and his jaws tired after eating, as he had not masticated for eleven years.

On the following day he reported that he had suffered intensely with abdominal pain and eructations, but nevertheless had taken breakfast, lunch and dinner and had abstained from milk. I continued the treatment and directed him in addition to take sodium bicarbonate five or six times daily, to relieve flatulence.

On the third day he reported that he was doing fairly well but still suffered considerably an hour or two after eating.

On the fourth day he was about the same. I discontinued salicin and prescribed naphthalin, five grains every four hours. During the entire treatment he took sodium bicarbonate freely and as often as he felt much discomfort from flatulence.

On the fifth day, having eaten like other persons from the beginning of treatment, taking no milk, he had slightly improved. He thought the naphthalin gave him considerable relief.

On the sixth day he was doing very well and the treatment was continued. He had become so much encouraged that on the fifth and sixth days he took supper late at night, with some excess in eating and drinking.

On the seventh day he was not so well. The indiscretions in diet of the fifth and sixth days, as he thought, gave rise to considerable pain with flatulence and vomiting. At night on the sixth day he took about half a pint of milk, which gave great relief. I discontinued naphthalin, substituting five grains of salol every two to four hours, and allowed a glass of milk at night.

On the tenth day he reported that he had done fairly well. The treatment was continued, with the addition of a glass of milk on rising in the morning.

On the twelfth day he had improved, the salol acting well. The treatment was continued.

On the fourteenth day he reported as not so well, having had a great deal of flatulence. I continued salol and prescribed ten grains of salicin before eating.

On the sixteenth day he was about the same. I prescribed a teaspoonful of listerin after eating.

On the twentieth day he reported no progress. The listerin seemed to have no effect. I discontinued listerin and prescribed ten grains of menthol as required.

On the twenty-third day he reported that the menthol seemed to act unfavorably. I then discontinued other remedies and prescribed ten grains of bismuth subgallate three times daily after eating. On the following day he went to Washington for six days.

On his return from Washington (the thirtieth day) he reported that his diet had been unrestricted and that he had been perfectly well since first taking bismuth subgallate. From time to time he took, in addition to bismuth subgallate, sodium bicarbonate to relieve slight flatulence with eructations. He then left the city for an extended journey abroad.

In May, 1893, six months after, I received a friendly letter from the patient, in which he made no mention of any digestive disturbance.

In August, 1893 the patient called upon me and reported that he had travelled extensively, at times subjected to very unfavorable conditions of diet; that he had been perfectly well and strong; had lost some flesh, which he regarded with satisfaction; had taken very little sodium bicarbonate, and occasionally, though rarely, a few doses of bismuth subgallate. His diet was unrestricted and he considered himself permanently cured.

I have given rather an extended account of this case to illustrate the unsatisfactory results following the administration of a great variety of antifermentative remedies until bismuth subgallate was prescribed. This remedy promptly produced marked improvement; and in the light of my subsequent experience, it seems to me that if it had been used earlier the recovery would have been much more speedy.

It was not my intention to discuss the question of diet in the causation and treatment of fermentative dyspepsia. Of course, a cure is established only when a diet practically unrestricted may be used with impunity. During the treatment of these cases, patients are simply directed to avoid excesses in food and drink and to eat little or no pastry or sweets.

XXXVI

A CASE OF FILARIA SANGUINIS HOMINIS, WITH CHYLURIA, TREATED SUCCESSFULLY WITH METHYLENE BLUE *

Published in the "New York Medical Journal" for June 15, 1895.

My election to the presidency of the New York State Medical Association for 1895 carries with it the honor of presiding over the meeting of the Fifth District Branch. My thanks for this evidence of confidence and regard on the part of the Fellows of the State Association can be more appropriately expressed on another occasion. At this meeting I shall content myself with endeavoring to add a little to the value and interest of your proceedings by reporting an unusual case with a novel method of treatment. I beg that you will accept this small contribution as an evidence of my appreciation of the privilege of presiding over your deliberations and discussions.

I find in my records of thirty-three years ago (March 20, 1862) brief notes of an examination of a specimen of chylous urine sent me by the late Dr. Isaac E. Taylor. About two years later I had an opportunity of examining another specimen from the same patient, the urine still being chylous. I have no notes of the history of this case beyond those of the examinations of the urine; and I regarded it simply as a curious observation. In the works on urinary diseases, a number of cases of chylous urine had been reported with no very definite ideas of the pathology or the therapeutics of this condition. Nearly if not all these cases had resisted a great variety of measures of treatment. It is stated by all writers, however, that chylous urine is peculiar to tropical countries.

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* President's address, Fifth District Branch of the New York State Medical Association, eleventh annual meeting, May 28, 1895.

Before 1868 I did not keep a full record of my urinary examinations, but I had never seen a case of chylous urine before I examined the specimens sent to me by Dr. Taylor. I now have records of examinations of urine of eight hundred and twenty-eight patients in private practice since 1868. During fourteen years' experience as medical examiner for a life-insurance company (1871 to 1885) I examined the urine of about two thousand applicants for insurance, who supposed themselves to be in perfect health. I never met with an instance of chylous urine, except a specimen that I examined in March, 1894, in probably more than three thousand examinations.

The pathology of chyluria and its relations to the filaria sanguinis hominis was first described by Timothy Richards Lewis, Surgeon Major, H. M. Army, in an article entitled "On a Hematozoon Inhabiting Human Blood; its Relations to Chyluria and other Diseases." Calcutta: Government print, 1872. A more complete account is given by Lewis in Quain's "Dictionary of Medicine," article Chyluria. In 1861–'62 Dr. Vandyke Carter attributed chyluria to a direct admixture of chyle and urine, "a leak from the lymphatic tract into the urinary." In 1870 Lewis found, in a specimen of chylous urine, "numerous microscopic nematoid worms in a living condition"; and in 1872 he found a number of the same worms "in a state of great activity on a slide containing a drop of blood from the finger of a Hindu." In recent works on pathology the parasites are described as larvæ of "filaria Bancrofti, a threadlike worm, eight to ten centimetres long, which inhabits the lymphatics of the scrotum and lower extremities, and is said to cause lymphstasis, with edema and a thickening of the tissue of the nature of elephantiasis, or lymphatic abscesses, chylous hydrocele and chylous ascites. The ova or larvæ—the filaria sanguinis—pass from the lymphatics of the scrotum and extremities to the rest of the lymphatic system and to the blood (into the latter, however, for the most part, only during rest at night), and may then give rise to hematuria, chyluria, and chylous diarrhea" (Weichselbaum, "Pathological Histology," London, 1895, p. 180). The larvæ found in the blood are in active movement and have "a length of 0.34 millimetre and a breadth of 0.0075 milli-

metre, a rounded-off head with a tongue-like process, and a pointed tail."

It is stated by all observers that in patients affected with filaria sanguinis the parasites disappear from the blood during the daytime and reappear at night; but when the patient sleeps during the day and is active during the night, the parasites appear in the daytime and are not found at night. According to universal experience the results of treatment have been unsatisfactory.

On March 3, 1894, I received from Dr. Joseph N. Henry, of New York, a specimen of chylous urine. I made an examination of this urine with the following result:

The specimen was white and opaque, like milk, with a very slight reddish-yellow tinge. The reaction was acid and the specific gravity was 1021.5. There was no urinous odor. A portion of the urine agitated with an equal bulk of ether became nearly clear. The specimen contained thirty-nine per cent. in volume of albumin. The albumin being removed and the urine filtered through animal charcoal, the filtrate was found to contain 7.25 grains of urea per fluidounce. There was no sugar. On standing for twelve hours there was a whitish sediment streaked with red. Microscopical examination revealed minute fatty granules, red blood-corpuscles, a very few oil globules, a very few leucocytes and bacteria.

I reported to Dr. Henry that the specimen was chylous urine, probably from a native of the tropics, and associated with filaria sanguinis. Dr. Henry invited me to see the patient and has sent me a history of the case.

Having had considerable experience in the use of methylene blue in malarial disorders, and in view of the action of this remedy on the plasmodium malariæ, it occurred to me that it might have a similar effect on the filaria. I accordingly suggested to Dr. Henry to give the patient two grains of methylene blue every four hours during the day and to note the effect upon the patient and upon the parasite.

The following history was sent to me by Dr. Henry:

"J. H., born in the isle St. Kitt's, West Indies, twenty-two years old, colored, well developed and muscular; occupation, bar porter; ten months in this country; family history good; never ill

before; presented himself to me, March 2, 1894, with the following symptoms: Headache, pain in the small of the back, one degree elevation of temperature, with a history of rapid emaciation and muscular weakness. He handed me a specimen of his urine, which looked like rich milk, being perfectly opaque, with no tendency to precipitation. Chemical examination showed the following: Specific gravity, 1014; reaction slightly acid; after filtration, approximately two per cent. of albumin; no sugar. Upon agitation of the urine with ether it became perfectly clear, demonstrating the presence of emulsified fat in large quantity. Microscopical examination showed large quantities of finely divided fat globules, chyle corpuscles, and a considerable quantity of apparently broken-down matter. No casts were discovered, but there were a few blood-corpuscles. From the foregoing history and symptoms I arrived at the conclusion that the patient was suffering from chyluria, a disease which is seldom found in the temperate zone, but is more or less frequently found in tropical or semitropical countries, my attention having been called to it by a case which I saw in Singapore some years ago, the disease being due to the fact that the lymphatics become the habitat of one or more animal organisms known as filaria sanguinis hominis (this condition was first described by Lewis in 1872), and that the embryos are thrown out in large quantities into the blood-current. I immediately began a series of examinations of the patient's blood. My first examination was made at the man's home on March 3, at 12.30 A. M., it being a well-recognized fact that the embryonic filaria is rarely if ever found during the daytime in the blood of the sufferer, unless through his occupation he inverts the usual order of his life and works during the night; then they may be found in the blood during his period of rest from physical and mental labor—that is, during the day. I first took one specimen of blood from the right ear, placing it under a one-eighth-inch objective. I found in each field of the microscope an average of ten embryonic filariæ. Their diameter was that of a blood-corpuscle, their length being forty to fifty times their diameter. Their movements were extremely rapid, twisting and turning and quickly moving out of the field of view. They seemed to have a well-marked head, a cylindrical and striated body, terminating in a filament-like tail.

"On the following day I called the attention of Dr. Austin Flint and Dr. Austin Flint, Jr., to the case. Dr. Flint suggested the use of methylene blue in the treatment. On March 5 I administered to the patient two grains of methylene blue, and repeated it at intervals of four hours during the day. The same night, at eleven o'clock, the doctors Flint and I examined the blood with the microscope, and after searching four slides carefully, we were able to discover but two filariæ, they being extremely sluggish in their movements at that time and stained a decided blue, as was also the blood plasma to some extent. The urine in the meantime had entirely lost its milky and turbid appearance and had become perfectly transparent, but deeply stained with the characteristic greenish blue. The treatment was then discontinued, the blood

being examined during the 8th and 11th of March without finding any traces of the embryonic filariæ. On March 12 the urine had lost its blue color and again became milky. On the night of March 13 microscopical examination revealed the embryonic filariæ in considerable number; but at the same time there was considerable aniline staining, and their movements were much more sluggish than they were when I first had occasion to examine the blood. On that night I was accompanied by Dr. D. H. McAlpin, who took a specimen of blood to the Carnegie Laboratory for microphotography.

"On the following day the patient was again given the methylene blue, and on the third day thereafter the blood was examined for the organisms. Several dead and partially disintegrated filariæ were found, deeply stained with blue. The urine had entirely cleared, being found normal on chemical and microscopical examination, except its deep blue stain. The treatment was discontinued at the expiration of five days, and despite the fact that repeated microscopical examinations have been made, the embryonic filariæ have up to the present time (April, 1894) not reappeared. The urine remains normal, the patient having regained apparently perfect health."

The effects of the methylene blue in this case were decided and prompt. After the administration of two grains every four hours during the day on March 5, the parasites were very few at 11 P. M.; the only two found were deeply stained with blue and their movements were extremely sluggish, the urine being clear but intensely blue. On the fourth and the seventh days no parasites were found, although the treatment had been discontinued after the first day. On the eighth day the urine became milky, and on the night of the ninth day the parasites were found in great number, but their movements were not very active. On the tenth day the treatment was resumed and continued for five days. Three days after, the blood being examined at night, a very few motionless filariæ were observed. Since that time, and up to the present writing, the urine has been normal, and the patient has been restored to perfect health.

Judging from this single case, it appears that methylene blue is a prompt and efficient remedy for chyluria dependent upon filaria sanguinis hominis. In this instance more than a year has now elapsed without a return of the disease. This single experience points to the possibility of benefit from methylene blue in the treatment of other diseases due to the filaria, such as chylous collections in the peritoneal cavity and in the cavity of the tunica vaginalis testis, hematuria and elephantiasis.

About two years ago I made an observation on a perfectly healthy subject on the effects of methylene blue on the urine. An hour and a half after taking a grain and

a half of methylene blue the urine was distinctly colored. In two hours and a half the urine was intensely blue. The methylene blue was continued, a grain and a half three times daily, for three days, and twice daily for four days, without inconvenience. It was discontinued at the end of the seventh day. The urine gradually lost its blue color, but it did not disappear until about forty-eight hours after the last dose. During the administration of the drug the feces were colored blue.

I have used methylene blue with success in malarial enlargement of the spleen, in chronic cystitis and in a few cases of gonorrhea. I have given it in doses of a grain and a half to two grains in capsules two or three times daily. In a few cases it has produced some irritation of the neck of the bladder, but this has been exceptional. It has been recommended to give about thirty grains of powdered nutmeg with each dose of methylene blue, to guard against bladder irritation. In cases in which trouble of this kind has occurred I have corrected it easily with nutmeg. In malaria it has been found that methylene blue directly attacks the plasmodium and promptly relieves the symptoms in many cases; but the good effects are not so lasting as when the condition is overcome by quinine. This has been my experience; but in some cases of enlarged and painful spleen of malarial origin, which have resisted quinine, methylene blue has acted promptly and most satisfactorily. Having used this remedy for seven or eight days, I have discontinued it and substituted quinine in moderate doses and continued for several weeks, with excellent results.

I give my experience with methylene blue in gonorrhea with some diffidence, for the reason that my opportunities for testing it have been small and the results in the hands of others to whom I have suggested its use have not been entirely satisfactory. My attention was directed to its use in gonorrhea by an article by Dr. Max Einhorn, which appeared in the "Medical Record" for November 1, 1891. I was specially struck with the logic of this treatment for gonorrhea, as both methyl blue and methylene blue are used largely in staining the gonococcus. Urethral injections of methyl blue have been employed by Adler and others with only moderate success,

not enough to popularize the use in this way of a remedy so troublesome and uncleanly. It seemed to me, also, more rational to use it internally, according to the method of Dr. Einhorn, impregnating the urine strongly with it and depending on the frequent passage of the agent in this form over the affected surface. In a few cases of gonorrhea which were incidental to other diseases in the medical wards of Bellevue Hospital, I used methylene blue alone internally with great success. I kept no records of these cases and have records of but a few cases in private practice. The few cases that I have treated have been uniformly successful, with one exception. This patient had repeatedly suffered from gonorrhea and had a stricture and probably ulcerated spots in the urethra. He took methylene blue, a grain and a half twice daily. It seemed at first to relieve him and the discharge disappeared. On the ninth day, however, he drank some whisky and the discharge returned. He then took santal Midy, and the discharge was promptly arrested. I saw him but once, and he was exposed to considerable fatigue during the entire time of his trouble, travelling on business.

In two of my recorded cases the effects of the remedy were truly remarkable:

The first case was that of a man, thirty-five years of age, with a moderate but characteristic discharge that had existed for two or three days. He was put on methylene blue, a grain and a half three times daily, and had no other treatment. The next day the discharge was very much diminished and the ardor urinæ had disappeared. I saw the patient again on the ninth day and he was perfectly well. He stated that the discharge ceased on the fourth day. At the beginning of the treatment I suggested, as an experiment, that he continue his usual habits of moderate use of alcohol, with the idea that the impregnation of the urine with the remedy would counteract any local effects due to alcoholic indulgence. He told me, however, that for domestic reasons he was unwilling to submit to any experiment which could possibly retard a cure.

The second case was that of a man, fifty years of age, with his first attack, who was seen by me on the first day. In this case the gonococcus was discovered in the urethral discharge. The patient took two grains of methylene blue three times daily for three days and twice daily for four days. He habitually drank wine and beer and occasionally spirits. He readily assented to my proposition to drink as usual, and on the first day of treatment drank freely of wine and beer. During the last four days of treatment he exceeded his instructions to the extent of drinking very

freely, once or twice to excess and even to the extent of gross intoxication. There was great diminution in the discharge on the first day of treatment, and the patient was entirely well on the seventh day.

The cases of gonorrhea that I have treated in private practice have been in patients who had regarded me as their physician and were unwilling to make their troubles known to a stranger. I have treated these cases more or less under protest, with the understanding that they were to go to a specialist if the disease did not progress favorably toward a cure. My treatment was, indeed, experimental (but with the full knowledge and consent of the patients) as I do not pretend to treat gonorrhea according to the modern accepted methods. My small experience, however, goes to confirm the observations of Dr. Einhorn, although I used methylene blue instead of methyl blue. It seems to me that the agent used will attack and destroy the gonococcus unless the organism has penetrated deeply into the mucous membrane. It must be, it would seem, an efficient therapeutic measure to secure the frequent passage of urine, strongly impregnated with an agent destructive to the specific cause of the disease, over the entire mucous surface affected. Immoral as it may appear, and certainly improper to suggest to the laity, it is a reasonable scientific proposition, which is suitable for this time and place, that methylene blue would probably act as a prophylactic against gonorrheal infection in impure intercourse.

I fear that I have exceeded the limits of length which are justified by the small actual material on which this address is based; but I have thought it better to occupy your time with a slight contribution to the scientific proceedings of the Association than to endeavor to entertain you with generalities which might be neither useful nor interesting.

MISCELLANEOUS

INCLUDING ESSAYS AND ARTICLES ON DIETETICS, GYMNASTICS AND ATHLETICS, CRIMINOLOGY AND MAGAZINE ARTICLES

XXXVII

REPORTS ON DIETARIES FOR BELLEVUE HOSPITAL, PENITENTIARY, WORKHOUSE, ALMSHOUSE, LUNATIC ASYLUM, PARALYTIC AND EPILEPTIC HOSPITAL, CHILDREN'S NURSERIES, INFANTS' NURSERY AND NAUTICAL SCHOOL SHIP

Published in the Minutes of the Commissioners of Public Charities and Correction, New York, 1867 and 1869.

BELLEVUE HOSPITAL

In estimating the proper daily ration for the inmates of a pauper institution, like the Bellevue Hospital, I conceive that it is legitimate to discard, as impracticable and unnecessary, the ration which has been found necessary in the alimentation of armies and of able-bodied men from whom a definite amount of physical labor is to be exacted. Again, there is no parallel between the military and the civil hospital; for the former is conducted for the purpose of returning men in good physical condition as speedily as possible to the arduous duties of a soldier's life, the intention, also, being to discharge those who will never be fit for duty. The soldier is allowed by law a certain quantity of food, or its equivalent in money, for his support; and it is expected that the alimentation of hospitals shall be regulated by the surgeon in charge with reference to a definite sum of money which he is allowed to expend for each inmate.

In pauper institutions for the sick, my impression is that it is the intention to provide food in sufficient quantity and proper form for the support of the inmates; and it is no part of the idea of the management of such institutions to exact labor from patients, beyond the light work which they are willing and able to perform, and

which may seem desirable simply as a matter of occupation or from its favorable influence upon the physical and mental condition. It has been found by physiologists that men and women placed under these conditions do not require the quantity of nutritive matter that would be demanded by the system if they were in full health and habitually performing the ordinary labor of persons of their class. It is nevertheless a duty on the part of those who have their physical welfare in charge, to see that their food is sufficient for the demands of the system, so that they may not be discharged from the institution in a physical condition which renders them incapable of the labor immediately necessary to their support, as the result of deficient alimentation in the hospital. The moral considerations connected with this question are sufficiently evident.

It is manifestly the duty of those in charge of public hospitals to derive all possible benefit, so far as regards the physical condition of the inmates, from the raw material used in alimentation; and with this end in view, it is necessary to prepare the food in accordance with certain established scientific principles. These considerations particularly recommend themselves, as they do not involve, as a rule, much increase in the outlay for raw material and as the labor incident to the careful preparation of food can easily be procured without additional expense. It is desirable, also, to establish a regular dietary that will answer for the great majority of the population of the hospital and will consequently do away with much of the necessity for stimulants and extra diet prescribed by the attending physician; always bearing in mind the fact that any regular diet scale must be changed by the physician for many cases.

In suggesting modifications in the present dietary of the hospital, I shall start upon the requirements of a man in full health, modified to suit what may be supposed to be the average requirements of the inmates of the hospital. I have before me, not only the present dietary of the Bellevue and the Charity Hospital, but the scale of diet of all the hospitals in the city of New York. I shall not attempt to criticise the diet of other hospitals or to compare the alimentation of the different public institutions, but en-

deavor to point out necessary and practicable improvements in the quantity, quality and mode of preparation of food in Bellevue Hospital.

A healthy man discharges from the body about two thousand grains of nitrogenous matter, and nearly two and a half times that quantity of carbon, making in all a loss of about one pound of solid matter. Supposing the diet to consist of bread and lean meat in what have been found to be the most favorable proportions, to supply this waste he should receive about thirty-five ounces of bread and about ten ounces of meat, which contain a little more than two thousand grains of carbon. The diet-scale of Bellevue Hospital gives twenty ounces of bread, five ounces of boiled meat (which remains after eight ounces of meat have been boiled to make soup), two ounces of milk and one ounce of sugar. In addition, patients have one pint of soup and two pints of tea, with potatoes, twice a week. I assume that from the soup and meat each patient gets the equivalent of eight ounces of meat. The tea can be regarded only as an accessory aliment and is not to be directly considered in estimating the absolute quantities of nitrogenous matter and carbon received.

The following are the quantities of nitrogenous matters and carbon roughly estimated for the present hospital ration:

	Nitrogenous matter.	Carbon.
Bread	570 grains.	2,630 grains.
Meat	720 "	384 "
Milk	40 "	75 "
Sugar	00 "	180 "
Total	1,330 "	3,269 "

If this dietary were strictly followed, it would prove insufficient in quantity; but I am informed by the warden of the hospital that the quantity of bread is not restricted and those who desire more than the average above given obtain it. The quantity of meat, however, is insufficient; and this probably is the main cause of the almost universal necessity for extra diet. This same difficulty formerly existed in the hospitals of Paris; and a commission, composed of the highest authorities on these subjects, reported improvements in diet, as well as other hygienic conditions, which were proposed with a view of

abolishing orders for special diet, except in extraordinary instances. This commission, of which M. Payen was president, recommended an allowance of about sixteen ounces of raw meat (which was assumed to be equivalent to about eight ounces of cooked meat) to each person—one-half of the meat to be used in making soup and the remainder to be roasted. The allowance of bread recommended was about twenty ounces. This report will be referred to again in connection with the preparation of food.

In connection with certain improvements in regard to variety of food and its preparation, I suggest that the allowance of meat for each patient be increased to at least ten, and perhaps twelve ounces; the allowance of bread remaining the same.

The quality of the beef used in the hospital is not the most economical or the best for the patients. Instead of using exclusively what is known as the "chuck" and the shoulders, or the inferior parts of the fore quarter, the round should be used in addition; the parts from the fore quarter being used only in making soup. In the report from St. Luke's Hospital, it is stated that "the rounds of beef are more juicy and nutritious and more economical than the lower priced fore quarters. The latter, consequently, is never purchased by us." The average consumption of beef by the inmates of "St. Luke's" is a little more than eight ounces per diem for each patient.

It is desirable to alternate the ration of fresh beef with mutton, with round of beef slightly corned and with salt pork. This variety in meat diet has been found by physicians to be essential to proper nutrition. It is unnecessary to discuss further a fact so well established.

Vegetables are not used in the hospital in sufficient abundance or in proper variety. With the class of patients that forms the great majority of the inmates of other institutions, potatoes are almost a necessity; and these should be given every day instead of twice a week. Turnips, cabbages, parsnips, onions, etc., should be occasionally served separately as vegetables, as well as used in making soup. Dried beans and peas should also be used, made into soups or purées, and served separately. It is desirable, and not expensive, to give patients hominy

occasionally in alternation with corn meal. The bread should be made invariably of wheaten flour without admixture. In the present way of making soup, quite a number of vegetables, barley, turnips and parsnips, with broken bread and Indian meal are used. In addition to these, onions and carrots should be used.

Patients should get butter with their bread at least once a day, at tea, and butter might be given at breakfast; but molasses may be substituted in the morning without great disadvantage. At present patients get no butter, and all who have extra diet seem to crave fatty soups. Sugar and milk are issued in sufficient quantity.

Patients are now allowed salt and vinegar, but they should also have mustard when they desire it.

Both coffee and tea should be used in the hospital. When these articles are pure they are economical, as they enable the system to be sustained upon a quantity of nutriment less than would be required if they were not used. Coffee should always be purchased in the berry; for although adulterated articles may be as agreeable as the inferior grades of pure coffee, the favorable effects on nutrition are not obtained by their use. Coffee should be issued at breakfast, and tea in the evening; but tea may be taken in the morning by those who desire it, as these two articles have sensibly the same general effect. One of the most beneficial effects of these articles on hospital patients is in promoting cheerfulness. The article used in the hospital is an inferior grade of green tea. This is more frequently adulterated than black tea, and its effects are almost always unpleasant. Black tea should always be used. If the nervous disturbances ordinarily produced by green tea have not been observed in the hospital, it is because the quantity issued has been small and the article itself probably is not perfectly pure. The tea should never be boiled, for the aroma upon which much of its beneficial influence depends is then lost.

I have carefully examined the methods of cooking for patients in the hospital. This resolves itself into the making of soup and bread, as these are the main articles of diet. The method of making bread I did not examine; but the bread itself I found to be of good quality. I have some criticisms to present on the making of soup.

The quantity of meat used in preparing the soup is apparently sufficient. The cook could not give me the exact proportion, but estimating eight ounces for every pint of soup, which is boiled down from twice the quantity of water, the proportion of meat is originally forty pounds to twenty gallons of water; and this boiled down one half makes eighty pounds of meat to twenty gallons of soup. The meat is cut into pieces weighing seven or eight pounds each before boiling. The vegetable matters used are chiefly barley and Indian meal, with broken bread. Turnips or parsnips are used about half the time. No carrots are used. Onions are never used, but leeks are used when in season. The soup is boiled for three hours and is then taken out and immediately served. Skimming is begun about half an hour after the soup is put on; but the fat is not thoroughly removed. The barley and meal are put in immediately, and the other vegetables about half an hour before serving. Any scrap that may be left is put in and boiled with the rest the next day, after removing the fat from the top. With one pint of soup, about five ounces of soup meat are served to each patient. When mutton soup is made, about twenty-five per cent. more meat is used. One pint of soup, five ounces of boiled meat, and bread in variable quantity constitute the ordinary dinner. Every Friday mush and milk are substituted for soup and meat.

The faults in this mode of making soup are the following:

The soup is boiled down briskly; and in this way the aroma is lost and the meat is hardened and not well extracted. The soup is not properly seasoned and is too greasy. There is no opportunity to vary the strength of the soup, and it can be used only for ordinary diet and never as extra diet. It is desirable to make a soup which could be used undiluted or slightly diluted for extra diet, and be considerably diluted for ordinary diet. In this important item in cookery I do not think that the formula used in the hospitals of Paris can be improved upon. This formula is the result of careful scientific inquiry. It makes a broth which can be used undiluted as beef tea, and it may be largely diluted for soup. If this were used in the Bellevue Hospital, the visiting physician would know pre-

cisely what his patient was receiving when he ordered soup or broth.

FORMULA FOR MAKING SOUP—(TWENTY GALLONS OF BROTH)

Water	20	gallons.
Meat, weighed with the bones	70	pounds.
Vegetables	15	"
Salt (white)	$1\frac{3}{4}$	"
Burnt onions (baked in an oven until desiccated)	$\frac{1}{2}$	"

The capacity of the kettles should not exceed twenty gallons, as in larger vessels the pressure on the lower strata of the liquid causes the temperature to rise too high and the aroma is thereby in part destroyed. The meat should be cut from the bones and tied with strong cords into packages of nine or ten pounds each. The bones should be broken up and placed in the bottom of the kettle. The packages of meat should then be placed on a perforated false bottom or a grating, above the bones. Twenty gallons of cold water are then poured in, the whole is raised to the boiling point and the scum is removed as it forms. It is kept simmering for two hours, during which time it is constantly skimmed. Between the first and second hour, when the skimming is nearly completed, the vegetables, with the burnt onions, are introduced enclosed in a net-bag. (The burnt onions may be omitted, as they are used only to give a dark color to the soup.) A gentle ebullition is then kept up for four or five hours. The fire is then extinguished, and after about an hour the vegetables, the meat and the bouillon are taken out. When the latter is to be used, the congealed fat is taken from the top and the bouillon is mixed with about an equal quantity of water and heated to make the soup. The vegetables to be used are cabbages, carrots, onions and turnips or parsnips. The clear bouillon may be used as beef-tea, or it may be diluted according to the direction of the physician.

In this process the nutritive value of the meat is nearly destroyed, and it can only be used afterward mixed with vegetables in the form of hash or made into an Irish stew.

The commission on the alimentation of the French hospitals recommended unanimously that patients should

receive roasted meats. This is absolutely necessary; the system can not be properly nourished when boiled articles alone are used. It is indispensable that arrangements be made at Bellevue Hospital for roasting on a large scale, as well as baking occasional articles. I indicate what seems to me to be the proper amount of roasted meats in the scale of diet for the week. It is desirable, also, to serve once or twice a week, a rice, bread or Indian pudding; which could be done without much expense, if there were arrangements for baking on a large scale. In this way the broken bread of the week could be used very satisfactorily.

The entire arrangement of the cookery department seems to me to be defective, from want of knowledge and experience in the "head cook," if he may be so called, and an insufficient number of intelligent subordinates. To cook for six or eight hundred patients requires a well regulated organization, under the direction of a trustworthy superintendent, who is an educated and experienced cook. The services of such a person, even if paid a high salary, would be a saving to the institution; for all the nutritive material would be used, the diet of patients would be immensely improved, they would consequently recover more rapidly and remain less time in the hospital, and the quantities of stimulants and extra diet required would be diminished to a fraction of what are at present used. All these advantages were considered by the French Commission already referred to; and they recommended extensive improvements in the dietaries of the Parisian hospitals, on economical as well as humanitarian grounds.

The following diet scale, if adopted in substance, would, I believe, produce many of these good results:

PROPOSED DIETARY FOR THE SICK

MONDAY

Breakfast—Coffee or tea, with milk and sugar; mush with molasses or milk; bread and butter.

Dinner—Irish stew; potatoes; bread.

Supper—Tea, milk and sugar; bread and butter.

TUESDAY

Breakfast—Coffee or tea, milk and sugar; boiled beans; bread and butter.

Dinner—Soup; boiled or roasted mutton; potatoes; bread.

Supper—Tea, milk and sugar; bread and butter.

WEDNESDAY

Breakfast—Coffee or tea, milk and sugar; hashed meat well seasoned; bread and butter.

Dinner—Irish stew; potatoes; bread; baked Indian, rice or bread pudding.

Supper—Tea, milk and sugar; oat-meal gruel or porridge of some kind; bread and butter.

THURSDAY

Breakfast—Coffee or tea, milk and sugar; boiled hominy, with molasses or milk; bread and butter.

Dinner—Soup; roast-beef; potatoes; bread. (Instead of beef, baked beans and pork may be given occasionally.)

Supper—Tea, milk and sugar; bread and butter.

FRIDAY

Breakfast—Coffee or tea, milk and sugar; mush, with molasses or milk; bread and butter.

Dinner—Boiled salt codfish (fresh fish occasionally); potatoes; bread; hominy and molasses.

Supper—Tea, milk and sugar; bread and butter.

SATURDAY

Breakfast—Coffee or tea, milk and sugar; hashed meat well seasoned; bread and butter.

Dinner—Boiled beef slightly corned, with boiled cabbage or turnips; potatoes; bread.

Supper—Tea, milk and sugar; bread and butter.

SUNDAY

Breakfast—Coffee or tea, milk and sugar; boiled hominy, with molasses or milk; bread and butter.

DINNER—Roast beef; potatoes; bread; baked rice, Indian or bread pudding.

SUPPER—Tea, milk and sugar; bread and butter.

In the above diet scale there are a few radical changes from the present dietary of the hospital, the most important of which is the substitution on many days of roasted meats for soup with the scrap meat, and the suppression of the ration of soup-meat, except in the form of hash for breakfast. Another important change is the addition of butter to the ration. This should certainly be given at supper, but it may be omitted at breakfast.

Finally, the important requirement of variety in diet is met. At breakfast the addition of mush, hominy, beans, hash, etc., will not increase the cost of maintaining the patient, for the consumption of bread will be correspondingly diminished. It will undoubtedly involve more labor, but this should not be considered when unpaid labor is so easily procured. With such a diet scale as the above, extras would not be required except in nursing women or in cases of disease in which vigorous sustaining measures are indicated.

In addition to the above recommendations it is suggested that a pint of milk and one egg be added to the ration of each woman who has been confined.

ALMSHOUSE, WORKHOUSE AND PENITENTIARY

The committee of which I am chairman has made a thorough and careful examination of the dietaries and the mode of cooking and serving the food at all the above-named institutions; and in the report, I shall take up the dietary of the Workhouse and Penitentiary together, as the food served at these institutions is nearly identical, and the dietary suited to one is applicable to the other.

In considering the dietaries of these institutions I fully appreciate the proper difference between a penal diet and that which should be furnished to the sick poor and the unfortunate. I believe that the inmates of the penal institutions should be furnished simply with a proper quantity and quality of food, prepared so as not to be distasteful or to lose any of its nutritive properties. They are undoubtedly entitled to this, but to nothing more.

PENITENTIARY AND WORKHOUSE

The present dietary of the Penitentiary and the Workhouse appears to be sufficient in quantity and of proper quality. The prisoners now receive for breakfast each day, ten ounces of bread and a pint and a half of rye coffee sweetened with molasses; for dinner they have bread, with fresh beef five days in the week, and salt meat two days, both in sufficient quantity; and for supper they have ten ounces of bread and a pint and a half of rye coffee, alternating daily with mush and molasses and rye coffee.

For those who remain in these institutions for ten to sixty days, this diet is sufficient; except, perhaps, for the boatmen after exposure in bad weather, who then get more bread, with meat twice in the day, which seems proper; but for those who remain confined for a long time, the diet is somewhat deficient in vegetables. As a matter of economy, also, it would be well to have a good plain cook at each of the institutions, who should have charge of the cooking for the keepers, etc., and supervise the cooking for the prisoners, so as to see that nothing is wasted.

In accordance with these and other considerations, the following recommendations are presented:

That potatoes be issued twice a week; and that the meat-stews be made with a liberal quantity of fresh vegetables, the diet in other regards remaining as it is at present.

That a proper medical officer be directed to inspect the prisoners once or twice in the week, with power to excuse from work or transfer to the hospital those who may be ailing, and to order fresh vegetables or other changes in diet for those who may be suffering from monotony in diet and from long confinement. Most of these provisions are already carried out; but regular inspections of the physical condition of the prisoners are desirable.

Since the destruction of the mess-room of the Penitentiary, the male prisoners eat their food in their cells. This renders cleanliness more difficult and attracts rats and mice. It would be better to have the prisoners take their meals at the tables which have lately been constructed in one of the halls, or in some other suitable place.

ALMSHOUSE

The dietary of the Almshouse is not so good as at the penal institutions, except at the Hospital for Incurables, where it is all that could be desired. It is generally recognized that in institutions of this kind, the dietary should not be such as to offer a premium for pauperism; still, economy and the proper physical condition of the paupers demand that the food for the Almshouse should be good and be properly prepared.

In the first place, where there are twelve to fifteen hundred human beings to be fed, the preparation of the food should be under the direction of a competent and educated cook; and such supervision would be economical. When cooked food is to be carried from one building to another, it should be done in properly constructed covered vessels. The remarks on this point in the report on the dietary of the institutions on Randall's Island are applicable to the Almshouse, the Lunatic Asylum and the Paralytic and Epileptic Hospitals.

The present dietary of the Almshouse is as follows:

Breakfast and Supper, the same, and not varied during the week; viz., seven ounces of bread and a pint and a half of rye coffee, sweetened with molasses, at each meal.

Dinner—Two days in the week, one pound of fresh meat (weighed with the bones and uncooked) made into soup with vegetables. The paupers get about a pint of this soup with the meat, which after cooking weighs about eight ounces, and seven ounces of bread. Two days in the week, the dinner consists of three-quarters of a pound of salt meat, bean soup and seven ounces of bread. Two days in the week, soup is made with five hundred pounds of meat for twelve to fifteen hundred persons. About a pint and a half of this soup and seven ounces of bread are given to each one, and the soup-meat in addition is served to the men as far as it will go, the working men being preferred. On one day in the week (Friday) the dinner consists of mush and molasses.

This diet does not appear to be sufficient. From inquiries it seems that the average allowance of bread is less than most of the paupers would eat; and bread, as a rule, should be furnished without restriction. Certainly,

on some days, the meats should be baked or roasted. Instead of the constant ration of parched rye, coffee and tea should sometimes be served. Keeping in mind the character of the inmates of almshouses, it nevertheless seems that there should be some improvement in their diet, and the following changes are suggested:

DIETARY

SUNDAY

BREAKFAST—Rye coffee; boiled hominy, with molasses; bread.

DINNER—Roast beef; potatoes; bread; baked rice, bread or Indian pudding.

SUPPER—Tea, milk and sugar; bread and butter.

MONDAY

BREAKFAST—Coffee or tea, milk and sugar; bread and butter.

DINNER—Soup; boiled or roasted mutton; bread.

SUPPER—Rye coffee; bread.

TUESDAY

BREAKFAST—Rye coffee; boiled beans; bread.

DINNER—Irish stew; bread.

SUPPER—Tea, milk and sugar; bread and butter.

WEDNESDAY

BREAKFAST—Coffee or tea, milk and sugar; bread and butter.

DINNER—Soup; boiled or roasted mutton; bread.

SUPPER—Rye coffee; bread.

THURSDAY

BREAKFAST—Rye coffee; boiled beans; bread and butter.

DINNER—Roast beef; potatoes; bread.

SUPPER—Tea, milk and sugar; bread and butter.

FRIDAY

BREAKFAST—Coffee or tea, milk and sugar; bread and butter.

DINNER—Boiled salt codfish; potatoes; bread.
SUPPER—Rye coffee; mush and milk; bread.

SATURDAY

BREAKFAST—Rye coffee; boiled hominy and molasses; bread.
DINNER—Boiled beef, slightly corned, with cabbage or turnips; bread.
SUPPER—Tea, milk and sugar; bread and butter.

This table seems to present the proper variety of food in a suitable form. The paupers now get neither butter nor milk, both of which are articles too important to be neglected. It is desirable, also, that they should have potatoes at least every alternate day.

LUNATIC ASYLUM, PARALYTIC AND EPILEPTIC HOSPITAL

After a careful examination of the present dietaries of these institutions, it appears that many changes are called for as regards the quantity, variety and preparation of food, particularly for the Lunatic Asylum. The present table for the Paralytic and Epileptic Hospital is good; but the dietary for the Lunatic Asylum is decidedly inferior to that of the penal institutions, and is inferior even to the Almshouse diet. In fact, its dietary is by far the most unsatisfactory on the Island. Not only does the quantity of food seem insufficient, but the cooking is utterly unscientific and appears to be under no competent direction, although more than one thousand persons are fed from the cook-house.

The present diet scale at the Lunatic Asylum is briefly as follows:

The breakfast is the same every day in the week and consists of rye coffee, with milk and sugar, and bread.

The supper is also the same during the week, consisting of tea (one drachm for each person), with milk and sugar, and bread.

Three days in the week the patients get beef soup, with the soup-meat, and bread. The weight of the cooked meat, free from bones, is about one hundred and seventy

pounds for one thousand persons. This small quantity is explained by the fact that before the regular diet is issued to the patients, meat is cut off by the keepers, for "extras" and for the Paralytic and Epileptic Hospital. Two days in the week the patients get mutton soup with the soup-meat, and bread. The quantity of meat used for one thousand persons is four hundred pounds, weighed uncooked and with the bones. On one day in the week, the dinner consists of bean soup with pork, and bread; and on one day (Friday), mush and molasses, and bread.

This diet is insufficient in quantity and the food is unskilfully prepared. That it does not present a proper variety is shown by the fact that cases of scurvy among the patients are quite frequent every spring. It is true that the insane are more liable than others to this disease; but it does not occur to any extent in asylums where the inmates are well nourished.

The following suggestions are made in regard to the dietaries of the Lunatic Asylum and the Paralytic and Epileptic Hospital:

A thoroughly educated, experienced and competent cook should have the immediate direction of the kitchen. This is more necessary in the Lunatic Asylum than in any of the institutions. The cook should follow a proper dietary table, but should be allowed to exercise a certain discretion in varying from the table occasionally, so as to break in upon the routine from time to time. In this institution it is of course a great advantage to have the constant personal supervision of a resident physician, who can regulate the variations from the regular diet that are required in special cases. The same variety in the modes of cooking; that is, roasting and baking, should be provided for here as in Bellevue Hospital; and care should be taken that the cooked food is transported from the cook-house to the different buildings, properly protected in suitable vessels.

Having provided for the proper preparation of food under the direction of a good cook, it is recommended that the dietary table now used for the Bellevue Hospital be adopted for the Lunatic Asylum and the Paralytic and Epileptic Hospital. The serving of food in a manner

adapted to the peculiar condition of the patients should be regulated by the resident physician.

CHILDREN'S NURSERIES ON RANDALL'S ISLAND

A careful examination has been made of the various departments on Randall's Island, except the Hospital Department, the dietary of which is already satisfactorily arranged, and information has been obtained by interrogating the cooks and other officials, as to the quantity and quality of the supplies furnished, the mode of preparation and the manner of serving the food to the children. This report will embody some general considerations concerning the alimentation of children such as are received into the institutions on Randall's Island, a review of the present dietary of the institutions and suggestions in regard to improvements which seem necessary and practicable.

The nurseries contain five to six hundred children of various ages, divided as follows: the Quarantine has fifty to sixty inmates, some of whom are permanent and others temporary, being removed, in about ten days after their admission, to the other departments. The permanent residents are two to fourteen years of age; and the temporary residents are five to fourteen. The population of this department is constantly changing, and the numbers are very variable. The Infants' Department has a population of about fifty, between two and five years of age. The other departments are, the Small Boys, about one hundred in number, with ages between five and seven; the Large Boys, about two hundred and fifty in number, with ages between seven and fourteen; and the Girls, numbering about one hundred, seven to fourteen years of age. The small boys and the girls take their meals together, and the large boys are served by themselves.

The small boys, the large boys and the girls are supplied from the main kitchen, where the food of all is cooked together. The Quarantine and the Infants' Department have each their separate kitchens and supplies.

In considering the diet of these children the sick are excluded, as they are immediately transferred to the hospital.

In the alimentation of the nurseries certain peculiar-

ities incident to the nutritive demands of the system in early life must be recognized. The inmates of the other institutions, being adults, have passed through the perils of childhood, and their constitutions have become fully developed. In them the nutritive demands of the organism are about equal to the waste and the discharge of worn-out matter in the form of excretions. If, either before or after their admission into the institutions, the supply of nourishment is slightly deficient, the system becomes reduced; but if this is not carried too far, a sufficient diet is capable of restoring nutritive activity, and they soon return to their normal condition. It is a fact well known to physiologists, that men who have arrived at full development are capable of enduring hardship and recuperating after privations which would produce permanent injury to the constitution in young persons on the threshold of adult life.

Children two to fourteen years of age are not capable of resisting bad alimentation, either as regards quantity, quality or variety. At that age the demands of the system for nourishment are in excess of the waste; the extra quantity being required for growth and development. If the proper quantity and variety of food is not provided, full development can not take place, and the children grow up, if they survive, into puny men and women, incapable of the ordinary amount of labor and liable to diseases of various kinds. This is frequently illustrated in the higher walks of life, particularly in females; for many suffer through life from improper diet in boarding-schools, due to false and artificial notions of delicacy or refinement. After a certain period of improper and deficient diet in childhood, the appetite becomes permanently impaired and the system is rendered incapable of appropriating the amount of matter necessary to proper development and growth.

These remarks are made in order to show the importance of proper alimentation in children, and to show, also, that their young and impressible organizations are more sensitive than the system of the adult, and consequently that their alimentation should be more carefully watched.

Again, there are many articles of food proper for the adult that can not be taken by children; and while, in the

latter, variety in diet is of great importance, it is more difficult to provide in public institutions. Children soon become disgusted with a monotonous diet, and lose that relish for, and keen enjoyment of food, characteristic of youth. The necessity of a varied diet for the adult has been fully considered in the report on the diet of Bellevue Hospital. It is sufficient to say that this seems even more desirable in the alimentation of children.

DIETARY OF THE QUARANTINE

(ESTIMATED FOR SIXTY INMATES)

At the Quarantine, breakfast and supper are the same throughout the week, while the dinners are more or less varied every day.

BREAKFAST, at 7 A. M.—Cocoa, a little more than half a pint for the smaller children and a little less than a pint for the larger children, with bread for the larger, and bread and butter for the smaller children. At this meal the bread is given in such quantity as the children desire. The cocoa is made in the following way:

One-half a pound of cocoa is boiled with four quarts of milk (American Condensed Milk Company's milk, to which four parts of water have been added),* and with water to make twenty quarts. To this are added two pounds of sugar.

SUPPER, at 5.30 P. M.—Bread and milk. The quantity of milk is half a pint to a pint for each child, according to age. The matron states that she does not consider it desirable to give the children at supper all the bread they can eat. One loaf of bread supplies about ten children; the quantity to each being graduated according to age.

DINNER, at 12 M.—The arrangement of the dinners is as follows:

MONDAY

Roast mutton with bread.

TUESDAY

Beef, potted or stewed, with bread.

* The milk referred to in this report is always to be understood as composed of one part of condensed milk to ten of water.

WEDNESDAY

Mutton soup, with the meat, and bread.

THURSDAY

Roast beef or potted beef with bread.

FRIDAY

Codfish or haddock, stewed with potatoes (ordinarily called "picked-up" codfish) with bread.

SATURDAY

Stewed beef with bread.

SUNDAY

Roast beef and mashed potatoes with bread. (During the hot summer months they have bread and milk, as much as they wish, for their Sunday dinner.)

The supply of meat to the Quarantine is twenty-five pounds of beef or mutton (with the bones) each day except Friday, when twenty pounds of fish are substituted.

There is not much to criticise in the dietary of the Quarantine. The quantity of meat is sufficient, and it is evidently well prepared, being cooked in the ordinary way, in a private kitchen. The quality of the cocoa is fair, although it might be improved by adding more milk. Potatoes should certainly be given more frequently. Crackers, between meals, are given to the smaller children. All the children, however, look well and seem properly nourished; and suggestions are deferred until the diet issued from the main kitchen is considered. The improved diet that will be recommended there should be applied to all the departments.

DIETARY OF THE INFANTS' NURSERY

(ESTIMATED FOR FIFTY INMATES)

As in the Quarantine, the breakfast and supper are the same every day in the week, while the dinner is varied.

BREAKFAST, at 6.30 or 7 A. M.—Cocoa, three-fourths of a pint to a pint, with as much bread as the children

wish. The cocoa is decidedly better than in the Quarantine. It is made with half a pound of cocoa, one and three-quarters of a pound of sugar, ten quarts of milk, and water added to make twenty quarts. This cocoa is as good as could be desired for children of the age of those in this department, and the quantity given to each child is sufficient.

Supper, at 5 P. M.—Bread and milk, with butter every alternate day. The quantity of milk is three-fourths of a pint to a pint for each child, and the children have as much bread as they wish.

Dinner, at 12 M., as follows:

MONDAY

Soup, made of mutton and vegetables, with bread.

TUESDAY

Beef-tea, with the meat, and bread.

WEDNESDAY

Roast mutton, cold slaw and bread.

THURSDAY

Meat and vegetable soup with bread.

FRIDAY

Codfish and potatoes with bread.

SATURDAY

Beef-tea, with the meat, and bread.

SUNDAY

Roast beef and mashed potatoes with bread.

All the children in the Infants' Nursery have crackers between meals.

The daily supplies of meat and fish are the same as at the Quarantine; viz., twenty-five pounds of beef or mutton each day except Friday, when twenty pounds of fish are substituted.

The diet at the Infants' Nursery seems rather better

than at the Quarantine. Here it is represented that the children have all that they can eat; and when any child asks for more it is always supplied. The cocoa is decidedly better than at the Quarantine, containing two and a half times more milk. With these exceptions, no remarks are to be made beyond what has already been said concerning the dietary at the Quarantine.

DIETARY FOR THE SMALL BOYS, THE LARGE BOYS AND THE GIRLS

(ESTIMATED FOR FOUR HUNDRED AND FORTY)

As in the other departments, the breakfast and supper are the same every day in the week, while the dinner is varied.

BREAKFAST—Cocoa, about one pint for each child, with about seven ounces of bread.

The cocoa is prepared as follows:—Two and a half pounds of cocoa, four and a half quarts of molasses, twenty-eight quarts of milk, and water added to make two hundred and twenty-five quarts.

SUPPER—Sweetened milk and water, about one pint for each child, containing twenty-eight quarts of milk, four and a half quarts of molasses, and water added to make two hundred and twenty-five quarts; bread, about seven ounces for each child.

DINNER:

MONDAY

Pea-soup and five ounces of bread.

TUESDAY

Roast beef (weighing eight ounces before roasting), five ounces of bread, and gravy thickened with flour.

WEDNESDAY

Roast beef (weighing eight ounces before roasting), five ounces of bread, and gravy without flour.

THURSDAY

Roast beef (weighing eight ounces before roasting), five ounces of bread, and gravy without flour.

FRIDAY

Three and one-tenth ounces of fish (weighed before boiling), three ounces of potatoes, four ounces of bread, and gravy with flour and butter.

SATURDAY

Boiled mutton (weighing eight ounces before boiling), one pint of soup and five ounces of bread.

SUNDAY

Roast beef (weighing eight ounces before roasting), a little less than half a pint of gravy made from the meat drippings with water added, and five pounds of flour to the whole (one hundred quarts), three ounces of potatoes and four ounces of bread.

The above diet table is believed to represent precisely what the children receive. The diet table furnished to the Committee by the Warden is somewhat different.

Attention will now be given exclusively to the diet furnished from the main kitchen; and the improvements which will be suggested are applicable also to the Quarantine and the Infants' Nursery. Although the diet in these departments is good, it is susceptible of some improvement; and it is desirable that the diet at the Quarantine should be brought fully up to the standard at the Infants' Nursery.

The quantity of meat furnished to the main kitchen is sufficient. From the report of the Commissary, it appears that two hundred and twenty pounds of meat are issued daily, with the exception of Friday, when ninety-five pounds of fish are substituted. Bread, which is of excellent quality in all the institutions, should be given to each child without restriction as regards quantity.

The deficiencies in the diet are as follows:

There is not sufficient variety. The breakfast and the supper should be slightly modified during the week, whereas at present they are absolutely uniform. The starchy element is somewhat deficient. Potatoes present this alimentary substance in the best form for assimilation, par-

ticularly in children. Potatoes are now given only on Friday and Sunday; whereas they should be given every day. This is important; for experience and physiological experiments have shown that starch is very favorable to the development of fat in the body; and, other conditions being fulfilled, the deposition of a proper quantity of fat is a good indication of the character of the general processes of nutrition.

The cocoa is not sufficiently rich. It contains enough cocoa, which is a substance resembling, in its effects, tea and coffee, though not so powerful. Children do not require these agents to the extent to which they are desirable in the adult, and the preparations of chocolate are undoubtedly the best that can be used. It would be well to alternate cocoa with plain chocolate and with broma, which are all about the same price. The chief nutritive element in the cocoa, as it is given to the children, is milk. This is not in sufficient quantity, although the use of condensed milk secures a good and uniform article. It is suggested that the cocoa, chocolate or broma be made as follows:

One-half pound of cocoa, or the other preparations; ten quarts of milk (made by adding four parts of water to one of condensed milk); ten quarts of water, the whole making twenty quarts; to be carefully boiled, thoroughly stirred, and about two and a half pounds of sugar to be added.

The milk given with bread for supper is much too dilute; and it must be remembered that milk presents in itself the very best nourishment for children, containing, as it does, a great variety of alimentary principles. One part of condensed milk is now diluted with thirty-two parts of water and is sweetened with molasses to make it a little less thin to the taste. The condensed milk should be diluted with about six parts of water, and in the main kitchen at least, sweetening is not necessary. Three-quarters of a pint to a pint of such milk, with bread, would make a sufficient, a healthful and a palatable supper for children.

The pea-soup as now prepared is not good. This is an excellent article of diet if skilfully made; but otherwise it is very distasteful to children. Small pieces of fried

bread in the pea-soup would also be much relished; but in case the soup is not very well made, its use should be discontinued.

Occasional stews instead of soups would be much better for the children and would undoubtedly be more relished.

Children do not use condiments freely, but it is desirable that their food should be carefully and not highly seasoned and that they should have vinegar occasionally. With this view, it is recommended that a small quantity of pickled cabbage or beets be issued about twice a week, served in separate dishes so as not to be mixed with the other articles.

It is desirable, also, that the children should have about twice a week, what would be considered by them as luxuries. A bread, or rice, or Indian pudding would answer this end and would undoubtedly improve the condition of the children.

Cooking.—After proper quantity and quality of supplies the question of cooking is of great importance. Ovens should be constructed for roasting and baking on a large scale, and every facility should be afforded for the careful and scientific preparation of food. Roasting (?) can not be well done in the steam kettles now used for that purpose. It is not necessary to discuss the questions of savings and the improvement in diet which would be brought about by the employment of an educated and responsible cook. It is possible that the saving alone would be so great that the question of salary paid to a competent person would not be of much importance. The chief fault to be found in the main kitchen is that the supplies, which are entirely sufficient, are not well prepared, and that consequently much must be wasted. The gravies are now frequently made by simply adding water to the meat drippings. Sometimes they are thickened with flour; but this should always be done, and they should be properly seasoned. Again, an uneducated cook has no resources if the supplies should accidentally be deficient for a day; while a good cook would always be equal to any such temporary emergency.

It is therefore recommended to employ a competent

male cook, who should have immediate charge of the main kitchen and exercise a supervision over the kitchens at the Quarantine and the Infants' Nursery. He should have for his general guidance a proper diet table, but should have a limited discretionary power which would enable him to vary the mode of cooking occasionally.

When the cooked food is to be carried from the main kitchen to other buildings, it should be carefully protected so that it may be hot and palatable when served. For this purpose large copper vessels with well-fitting covers should be provided. In ordinary tin pails the heat is not sufficiently well retained.

The following diet table will effect most of the improvements suggested:

MONDAY

Breakfast—Cocoa or broma; bread and butter.

Dinner—Mutton stewed with vegetables; potatoes, boiled or mashed; pickled cabbage or beets; bread.

Supper—Bread and milk.

TUESDAY

Breakfast—Hominy and milk or molasses; bread and butter.

Dinner—Roast beef, with gravy; potatoes, boiled or mashed; bread.

Supper—Bread and milk.

WEDNESDAY

Breakfast—Cocoa or broma; bread and butter.

Dinner—Stewed beef; potatoes, boiled or mashed; bread; rice, bread or Indian pudding.

Supper—Bread and milk.

THURSDAY

Breakfast—Cocoa or broma; bread and butter.

Dinner—Roast beef, with gravy; potatoes, boiled, mashed or fried whole in the meat drippings; pickled cabbage or beets; bread.

Supper—Wheaten grits and milk; bread.

FRIDAY

Breakfast—Mush and milk or molasses; bread and butter.

Dinner—Codfish or haddock, with potatoes; bread and butter.

Supper—Bread and milk.

SATURDAY

Breakfast—Cocoa or broma; bread and butter.

Dinner—Roast mutton; potatoes, boiled or mashed; bread.

Supper—Bread and milk.

SUNDAY

Breakfast—Hominy and milk or molasses; bread and butter.

Dinner—Roast beef, with gravy; potatoes, fried whole in the meat drippings; rice, bread or Indian pudding.

Supper—Wheaten grits and milk; bread and butter.

There are few changes to suggest in the dietary of the Quarantine and the Infants' Nursery. The only modifications that seem necessary are an improvement in the quality of the cocoa, by using more milk (equal parts of milk and water, as before suggested) in the Quarantine, the use of milk less diluted (six parts of water to one of condensed milk) for supper, and the addition, daily, of potatoes to the dinner at both the Quarantine and the Infants' Nursery.

DIETARY FOR BOYS—THE NAUTICAL SCHOOL SHIP MERCURY

MONDAY

Breakfast—Cocoa or coffee with molasses; boiled beans with a little salt pork; biscuit and butter.

Dinner—Beef; desiccated mixed vegetables; Indian pudding; biscuit.

Supper—Tea with sugar; biscuit and butter.

TUESDAY

Breakfast—Cocoa or coffee with molasses; boiled rice; biscuit and butter.

Dinner—Pork and beans; desiccated potatoes; flour pudding; biscuit.

Supper—Tea with sugar; biscuit and butter.

WEDNESDAY

Breakfast—Cocoa or coffee with molasses; boiled hominy; biscuit and butter; pickles.

Dinner—Preserved meat; desiccated mixed vegetables; rice pudding.

Supper—Tea with sugar; biscuit and butter; dried fruit.

THURSDAY

Breakfast—Cocoa or coffee with molasses; boiled beans with pork; biscuit and butter.

Dinner—Beef, desiccated mixed vegetables or potatoes; Indian pudding; biscuit.

Supper—Tea with sugar; biscuit and butter.

FRIDAY

Breakfast—Cocoa or coffee with molasses; boiled hominy; biscuit and butter.

Dinner—Salt codfish or fresh fish; desiccated mixed vegetables or potatoes; rice pudding; biscuit.

Supper—Tea with sugar; biscuit and butter.

SATURDAY

Breakfast—Cocoa or coffee with molasses; boiled rice; biscuit and butter.

Dinner—Pork and beans; desiccated potatoes; flour pudding; biscuit.

Supper—Tea with sugar; biscuit and butter.

SUNDAY

Breakfast—Cocoa or coffee with sugar; boiled hominy and molasses; biscuit and butter.

Dinner—Preserved meat; desiccated mixed vegetables; baked or boiled Indian pudding with raisins and molasses; biscuit; pickles.

Supper—Tea with milk and sugar; boiled rice; biscuit and butter.

A late supper should be given to those on watch at night, consisting of coffee and biscuit.

The steward should be instructed to make no restriction in the quantity of biscuit and to supply good cider vinegar in the quantity required.

In port, when fresh meat and vegetables can be obtained, these should be substituted for the salt and preserved meat every day except Friday. If fresh potatoes, carrots, turnips, cabbage and onions can be procured, these should also enter into the rations; potatoes every day, cabbage and onions once or twice a week, and a meat-stew, with a variety of vegetables, twice a week. In port the boys should have fresh bread frequently instead of biscuit. The facilities for procuring these articles will probably be so irregular that it does not seem necessary to make out a special table for diet in port.

The diet table above recommended is based to a considerable extent upon the U. S. Navy ration; but I have introduced a much greater variety, a larger proportion of sugar and butter, with rice, hominy, Indian and rice puddings, all of which are peculiarly adapted to the tastes and nutritive requirements of young boys. As regards quantities I suggest that a reduction of about fifteen per cent. from the Navy supply tables be made, except in the articles that are here introduced more frequently. The quantity, however, should be a matter of careful experiment, for growing boys can not well bear a deficiency in food or in its proper variety.

XXXVIII

REVISED REPORT ON DIETARIES AND FOOD SUPPLIES FOR STATE HOSPITALS *

Published by the State Commission in Lunacy in 1894.

THE reports from the State hospitals on the practical working of my suggestions on " Dietaries and Food Supplies," dated June 29, 1893, indicate that the supplies have been more than ample. In a general way the results of full trial show that my report of June, 1893 needs but little revision, although it was intended to be to some extent experimental. If my suggestions had been carried out less literally while adhering to their spirit and general features, no revision would have been called for; however, it is fortunate that my report has been followed exactly in so many instances, as this enables me to revise my original recommendations and now to prepare schedules which may be regarded as final and likely to stand the test of further experience. I have, therefore, to suggest the following corrected schedules:

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* In June, 1893, Prof. Austin Flint was requested by the Commission to prepare a report on dietaries and food supplies for the guidance of the State Hospitals in the preparation of monthly estimates under the operation of the State care act, which was to take effect October 1, 1893. As stated by Professor Flint, the schedule of allowances contained in his report was necessarily somewhat experimental, in view of the fact that he had found no dietary tables in use exclusively for the insane, either in Europe or the United States, and, therefore, it might require revision after a reasonable trial. After the expiration of one year, the Commission requested the several State Hospitals to suggest such modifications of the ration allowances as the year's experience had shown to be desirable, in order to secure the best results. Responses were received from all the Hospitals, and these were transmitted to Professor Flint, with the request that he prepare a revised report. . . . It should be understood that the dietary or ration allowance proposed by Professor Flint is designed for the general use of the Hospitals, exclusive of special or " extra " diet, which may be prescribed in the discretion of the medical officers.

Daily Ration

Meat, with bone, including salted meats, fresh and salted fish, and poultry	12	oz.
Flour, to be used in making bread and in cooking (may in part be substituted by corn meal and macaroni)	12	"
Potatoes	12	"
Milk	16	"
One egg	2	"
Sugar	2	"
Butter	2	"
Cheese	1	"
Rice, hominy or oatmeal	$1\frac{1}{2}$	"
Beans or peas (dried)	$1\frac{1}{2}$	"
Coffee (in the berry and roasted)	$\frac{5}{6}$	"
Tea (black)	$\frac{1}{8}$	"

In the purchase of beef it is recommended that with each whole carcass purchased, there be bought one fore quarter additional. This will give an extra quantity for soups and stews and provide additional roasting pieces for the officers' table. The clear meat of the parts that have been used in making soups may be served "braized," or otherwise prepared, from time to time. Although not so nutritious as when made of fresh meat, dishes prepared in this way may easily be made palatable, and they would agreeably vary the diet if not used too frequently. This recommendation is made to meet the suggestion of the Superintendent of the Middletown Hospital. In the purchase of mutton, veal, pork, etc., it is recommended, as a matter of true economy as well as contributing to the proper quality of supplies, to buy whole carcasses, not the inferior parts only, which latter usually contain a large proportion of bone. With the different classes of persons to be provided for—physicians, attendants, workers and non-workers, male and female—nearly every part of an animal can be profitably and economically used. In the purchase of certain other articles, such as coffee and tea, impurities or adulterations, even if not positively harmful, take away from nutritive efficiency and are not in the line of true economy. Flour, milk, eggs, cheese, potatoes, beans, etc., take the place to a certain extent of other articles that are more costly. It requires but little experience to learn that the waste of flour, milk, etc., of poor quality, involves more expense than the purchase of first-class articles.

Some parts of a bullock contain only 8 per cent. of bone; some parts contain 50 per cent. A high French authority (Payen) estimates that ordinary supplies of meat contain 20 per cent. of bone. The meat includes a considerable but variable quantity of fat. Veal should never be supplied unless it is of the best quality. The same remark applies to fresh pork. A calf when dressed should weigh about 130 pounds. A young hog when dressed should weigh 120 to 140 pounds. A dressed sheep should weigh 65 to 120 pounds. A dressed steer should weigh 650 to 900 pounds, the fore quarter weighing 190 to 250 pounds, and the hind quarter, 140 to 200 pounds. About 40 per cent. may be deducted for salt pork, hams or bacon. One of the great advantages of skilful cooking is that inferior parts of carcasses may be utilized in the making of nutritious soups, stews, etc., which will take the place to a great extent of more costly articles and give more satisfaction to patients. Vegetable soups, also, may be largely used with advantage.

One hundred pounds of flour will make 136 pounds of good bread. Corn meal may be substituted for flour, but to a limited extent, as it is less nutritious and often disturbs digestion. Macaroni may be substituted for flour, but only as an occasional luxury. Bread should be made every day, and what is left over should be used in cooking and not be served again. If bread is made during the night and the baking finished as early as 3 A. M., it may be served on the same day. If to be served the next day, it should be baked as late as practicable in the afternoon or evening. If bread is simply warmed through in the oven immediately before serving, the moisture absorbed by the gluten is driven off and the bread is made much more palatable and digestible; but bread should never be dried in this way more than once.

The use of fresh vegetables in season will permit a suspension or reduction of the rations of rice, beans and peas, with some reduction in the ration of potatoes. Fresh vegetables and fruits should be used freely. Onions should be used freely in cooking and should be served occasionally as a separate dish. I have long observed that onions are craved by inmates of hospitals. Turnips, parsnips, salsify, carrots and beets may not strictly be classed as fresh

vegetables, but they may be frequently used with advantage.

In the revised ration I have recommended $\frac{5}{6}$ oz. of roasted coffee instead of 1 oz. of green coffee, assuming that coffee, properly roasted, loses about 16 per cent. in weight. Coffee can be better and more uniformly roasted in large quantities and by experts than in a hospital. The coffee should be very finely ground before making the infusion.

The ration does not include condiments and other flavoring articles, syrup, molasses, preserves and compotes, such as apple sauce, apple butter, etc., which should be provided as occasion offers.

If men and women are supplied at separate tables, it will be convenient to make up the supplies for each from this daily ration. Five per cent. may be added for men and deducted for women, making a difference of 10 per cent. For workers an addition of 25 per cent. may be made to the rations of meat, flour and potatoes.

The modifications that have been made in the "Daily Ration" are the following:

Flour has been reduced from 16 ounces to 12 ounces. The Superintendent of the Binghamton Hospital says that the dietary is "more than sufficient to meet the general requirements of the patients in a hospital of this kind." The Superintendent of the Utica Hospital has used 11 ounces of flour and $1\frac{5}{16}$ ounces of corn meal instead of 16 ounces of flour. The Superintendent of the Middletown Hospital has used 14 ounces of flour instead of 16 ounces.

Potatoes have been increased from 8 ounces to 12 ounces. The Superintendent of the Rochester Hospital recommends that the ration of potatoes be doubled. The Superintendent of the St. Lawrence Hospital recommends that the ration of potatoes be increased to 12 ounces.

Milk has been doubled. This is recommended by the Superintendent of the Hudson River Hospital and by the Superintendent of the Rochester Hospital. The Superintendent of the Middletown Hospital recommends that the ration of milk be increased four times.

The ration of eggs has been reduced one half. It seems to be the general impression that this ration has

been too large. I suggest that eggs be made interchangeable with milk.

The ration of cheese has been reduced one half. The general impression seems to be that cheese is not relished by patients. I suggest that cheese be made interchangeable with butter.

Supplies for One Hundred Persons for Thirty Days

Meat, with bone, including salted meat, fresh and salted fish, and poultry, total		2,250	lbs.
Flour (may be in part substituted by corn meal and macaroni)		2,250	"
Potatoes		2,250	"
Milk		1,500	qts.
Eggs		250	doz.
Sugar		375	lbs.
Butter		375	"
Cheese		188	"
Rice	94		
Hominy	94	282	"
Oatmeal	94		
Beans or peas (dried)		282	"
Coffee		156	"
Tea		24	"

This table should be regarded as very elastic. I think experience has shown it to be more than ample, and that considerable saving may be made, especially when fresh fruits and vegetables are available at low prices. Keeping in view always a proper variety of food, all the articles should be considered interchangeable in quantities to about equalize the cost. Flour should be interchangeable, on this basis, with potatoes, rice, hominy and oatmeal. Butter and cheese may be interchangeable in the proportion of 1 pound of butter to 2 pounds of cheese; and eggs and milk, in the proportion of 2 eggs to 1 pint of milk. There are times when eggs may be substituted with advantage for meat. This may be done on the basis of 8 eggs for 1 pound of meat. When fruits, fresh and dried, are used in abundance, a reduction may be made in eggs, butter, cheese and milk. While the table is intended for patients not under extra diet and attendants only and I have suggested that 25 per cent. in the rations of meat, flour, and potatoes be added for workers, I am of the opinion that with careful management and good cooking, the supplies indicated for 100 persons for 30

days can be made to cover the entire population of most of the hospitals, including workers, patients under extra diet, and even the medical officers with their families, without deviating from the proper standard of supplies for ordinary patients.

In the estimates of certain articles, fractions have been disregarded. The estimates of eggs, sugar, butter, cheese, rice, hominy, oatmeal, coffee and tea are approximative, per 100 persons for 30 days, as it is not contemplated that each and every one of these articles will be supplied to every patient every day in the week. Therefore, the quantities given in the table of " supplies for 100 persons for 30 days " do not always correspond with the quantities given in the " daily ration." The daily ration is calculated exactly, according to the physiological requirements of one person; the monthly ration is approximative. The estimate of milk is approximative, one pint being calculated as equal to one pound.

XXXIX

REPORT ON DIETARIES AND FOOD SUPPLIES FOR THE STATE CHARITABLE AND REFORMATORY INSTITUTIONS REPORTING TO THE COMPTROLLER OF THE STATE OF NEW YORK (1895)

This report is now printed for the first time; and, so far as I know, its suggestions have not been adopted.

THE experience of one year—October, 1893 to October, 1894—in the use of a dietary prepared by me for the New York State hospitals was carefully studied and the criticisms and suggestions of the superintendents of the hospitals were tabulated and analyzed. This study led me to revise the dietaries in some particulars, more or less important; and the revised dietaries seem to be well adapted to the institutions for the care of the insane.

As regards the dietaries for officers, attendants, laborers and inmates employed in the institutions reporting to the Comptroller's office, I can do no better than adopt in the main the dietaries I prepared for the State hospitals; but the classes, ages, etc., of inmates of these institutions are so varied, that important modifications in the general dietary are necessary to meet different conditions. But few of the institutions can be grouped together; and I have thought it best to prepare separate dietaries for each one.

Officers, attendants, citizen laborers and inmates employed, except inmates of penal institutions, are entitled to a liberal and satisfactory diet. A suitable distinction between the officers and the attendants and workers can readily be made by selecting for the former the choice parts of meats and by substituting certain articles that may be classed as luxuries for articles of general supply, on the basis of equality in cost. As regards the general

classes of inmates, there usually exists no necessity for "building up" of the system, a most important element in the treatment of the insane. The few that require medical treatment are in the "hospital"; and the schedules are sufficiently liberal to allow for extra diet ordered by the physician. Criminals are entitled to no luxuries in the matter of diet. They should be provided only with a quantity and variety of wholesome food that will maintain health and strength. That infants, children and the aged require different dietaries is evident. It is evident, also, that facilities for growing vegetables and fruits, providing milk and eggs, raising pork, mutton, veal, etc., at certain institutions, should be taken into account in making requisitions for supplies; but these considerations can hardly find place in the schedules prepared. Good cooking, also, is important from an economical point of view.

It is hoped that the schedules prepared will be carried out in spirit and not necessarily to the very letter, except as regards cost. It would be a fair general rule to make substitutions from the very varied and liberal list furnished by the Comptroller's office, on the basis of cost.

The administration of institutions as regards food supplies calls for a high grade of executive ability and for intelligent and careful supervision. Where this exists, the schedules prepared can hardly fail to prove satisfactory; and in many institutions large savings may be made. In the matter of supplies, there is little economy in using any but the best material, except for the inmates of penal institutions, where it is not proper to buy the highest grade of meats or superfine farinaceous articles. Meats, flour, etc., should be good and nutritious; but this does not necessarily call for the purchase of stall-fed beef or fancy brands of flour. It is understood, therefore, that my recommendations involve the purchase of sound and pure articles of food, to be properly prepared and served. It is recommended, in the purchase of beef, mutton, etc., as a matter of economy as well as contributing to the proper quality of supplies, to buy sides of beef and whole carcasses of the smaller animals, not the inferior parts only, which latter usually contain a large proportion of bone. With the different classes of persons to be provided for—officers and their families, attendants, workers and non-workers,

male and female—nearly every part of an animal may be profitably and economically used. In the purchase of certain other articles, such as coffee and tea, impurities or adulterations, even if not positively harmful, take away from nutritive efficiency and are not in the line of economy. Flour, milk, eggs, cheese, potatoes, beans, peas, etc., take the place, to a certain extent, of more costly articles. It requires but little experience to learn that the waste of flour, milk, etc., of very inferior quality or damaged, involves more expense than the purchase of sound articles. In the purchase of beef, it is recommended that with each whole carcass purchased, there be bought one fore quarter additional. This will give an extra quantity for soups and stews and provide additional roasting pieces for the officers' table. The clear meat of the parts that have been used in making soups may be served "braized," or otherwise prepared, from time to time. Though not so nutritious as when made of fresh meat, dishes prepared in this way may easily be made palatable and would agreeably vary the diet, if not used too frequently.

Some parts of a bullock contain only 8 per cent. of bone; some parts contain 50 per cent. Ordinary supplies of meat contain 20 per cent. of bone. The meat includes a considerable but variable quantity of fat. Veal should never be supplied unless it is of the best quality. The same remark applies to fresh pork. A calf, when dressed, should weigh about 130 pounds. A young hog, when dressed, should weigh 120 to 140 pounds. A dressed sheep should weigh 65 to 120 pounds. A dressed steer should weigh 650 to 900 pounds, the fore quarter weighing 190 to 250 pounds, and the hind quarter, 140 to 200 pounds. About 40 per cent. may be deducted for salt pork, hams or bacon. One of the great advantages of skilful cooking is that inferior parts of carcasses may be utilized in making nutritious soups, stews, etc., which will take the place to a great extent of more costly articles. Vegetable soups, also, may be largely used with advantage.

One hundred pounds of flour will make 136 pounds of good bread. Corn meal may be substituted for flour, but to a limited extent, as it is less nutritious and often dis-

turbs digestion. Macaroni may be substituted for flour, but only as an occasional luxury. Bread should be made every day, and what is left over should be used in cooking and not be served again. If bread is made during the night and the baking finished as early as 3 A. M., it may be served the same day. If served the next day, it should be baked as late as practicable in the afternoon or evening. If bread is simply warmed through in the oven immediately before serving, the moisture absorbed by the gluten is driven off and the bread is much more palatable and digestible; but bread should never be dried in this way more than once.

The use of fresh vegetables in season will permit a suspension or reduction of the rations of rice, beans and peas, with some reduction in the ration of potatoes. Fresh vegetables and fruits should be used freely. Onions should be used freely in cooking and should be served occasionally as a separate dish. Turnips, parsnips, salsify, carrots and beets may not be classed strictly as fresh vegetables, but they may frequently be used with advantage. I indicate in the schedule roasted instead of green coffee, assuming that coffee, properly roasted, loses about 16 per cent. in weight. Coffee can be best and most uniformly roasted in large quantities and by experts. The coffee should be very finely ground before making the infusion. The schedules do not include condiments and other flavoring articles, syrup, molasses, preserves and compotes, such as apple sauce, apple butter, etc., which should be provided as occasion offers, in substitution for articles in the schedules, which may be in excess.

The schedules should be regarded as very elastic. Experience in the State Hospitals has shown that the supplies are more than ample, and that considerable saving may be made, especially when fresh fruits and vegetables are available at low prices. Keeping in view always a proper variety of food, all the articles should be considered interchangeable in quantities practically to equalize the cost. Flour should be interchangeable, on this basis, with potatoes, rice, hominy and oatmeal. Butter and cheese may be interchangeable in the proportion of 1 pound of butter to 2 pounds of cheese; and eggs and milk, in the proportion of 2 eggs to 1 pint of milk. There are occasions when

eggs may be substituted with advantage for meat. This may be done on the basis of 8 eggs for 1 pound of meat. When fruits, fresh and dried, are used in abundance, a reduction may be made in eggs, butter, cheese and milk. Finally, I suggest that a thoroughly competent male cook be put in charge of the kitchen in all institutions with 500 or more inmates; and that he be required to personally supervise all the cooking and not the cooking for the officers' table only.

SCHEDULE NO. I *

For All Officers, Attendants, Laborers, and Inmates employed—except for the State Reformatory at Elmira, in which Institution All Inmates are employed

	Daily ration.	Supplies for 100 persons for 30 days.
Meat, with bone, including salted meats, fresh and salted fish, and poultry	16 oz.	3,000 lbs.
Flour, to be used in making bread and in cooking (may in part be substituted by corn meal and macaroni)	16 "	3,000 "
Potatoes	16 "	3,000 "
Milk (one pint = 16 oz.)	8 "	750 qts.
Eggs (one egg = 2 oz.)	4 "	500 doz.
Sugar	2 "	375 lbs.
Butter	2 "	375 "
Cheese	1 "	188 "
Rice, hominy or oatmeal	1 "	188 "
Beans or peas (dried)	1 "	188 "
Coffee (in the berry and roasted)	$\frac{5}{6}$ "	156 "
Tea (black)	$\frac{1}{8}$ "	24 "

* This schedule applies to officers, attendants and citizen laborers at the State Reformatory at Elmira.

SCHEDULE NO. II

	New York State School for the Blind (Batavia). Ages—7 to 12 Years.		Northern New York Institution for Deaf Mutes (Malone). Ages—12 to 17 Years.		Syracuse State Institution for Feeble-minded Children. Ages—over 17 Years.	
	Daily ration.	Supplies for 100 persons for 30 days.	Daily ration.	Supplies for 100 persons for 30 days.	Daily ration.	Supplies for 100 persons for 30 days.
Meat, with bone, including salted meats, fresh and salted fish, and poultry	6 oz.	1,125 lbs.	8 oz.	1,500 lbs.	12 oz.	2,250 lbs.
Flour, to be used in making bread and in cooking (may in part be substituted by corn meal and macaroni)	6 "	1,125 "	12 "	2,250 "	12 "	2,250 "
Potatoes	6 "	1,125 "	12 "	2,250 "	12 "	2,250 "
Milk (one pint = 16 oz.)	16 "	1,500 qts.	8 "	750 qts.	8 "	750 qts.
Eggs (one egg = 2 oz.)	2 "	250 doz.	2 "	250 doz.	2 "	250 doz.
Sugar	2 "	375 lbs.	2 "	375 lbs.	2 "	375 lbs.
Butter	2 "	375 "	2 "	375 "	2 "	375 "
Cheese	......	....	......	....	1 "	188 "
Rice, hominy or oatmeal	3 oz.	563 lbs.	2 oz.	375 lbs.	1 "	188 "
Beans or peas (dried)	......	....	1½ "	282 "	1 "	188 "
Coffee (in the berry and roasted)	......	....	½ "	94 "	5/6 "	156 "
Tea (black)	......	....	......	....	⅛ "	24 "

SCHEDULE NO. III

Thomas Asylum for Orphan and Destitute Indian Children

	Ages—3 to 7 Years.		Ages—7 to 15 Years.	
	Daily ration.	Supplies for 100 persons for 30 days.	Daily ration.	Supplies for 100 persons for 30 days.
Meat, with bone, including salted meats, fresh and salted fish, and poultry	2 oz.	375 lbs.	6 oz.	1,125 lbs.
Flour, to be used in making bread and in cooking (may in part be substituted by corn meal and macaroni)	4 "	750 "	6 "	1,125 "
Potatoes	4 "	750 "	6 "	1,125 "
Milk (one pint = 16 oz.)	16 "	1,500 qts.	16 "	1,500 qts.
Eggs (one egg = 2 oz.)	......	....	2 "	250 doz.
Sugar	2 oz.	375 lbs.	2 "	375 lbs.
Butter	1 "	188 "	2 "	375 "
Rice, hominy or oatmeal	2 "	375 "	3 "	563 "

SCHEDULE NO. IV

New York State Reformatory at Elmira

	Daily ration.	Supplies for 100 persons for 30 days.
Meat, with bone, including salted meats, fresh and salted fish, and poultry	8 oz.	1,500 lbs.
Flour to be used in making bread and in cooking (may in part be substituted by corn meal)	12 "	2,250 "
Potatoes	12 "	2,250 "
Milk (one pint = 16 oz.)	4 "	375 qts.
Sugar	2 "	375 lbs.
Butter	1 "	188 "
Cheese	1 "	188 "
Rice, hominy or oatmeal	1 "	188 "
Beans or peas (dried)	2 "	375 "
Coffee (in the berry and roasted)	½ "	94 "

The New York State Reformatory at Elmira presents certain peculiar conditions. The inmates are young criminals, between 16 and 30 years of age, under sentence. On admission they are put in the lower-first, or intermediate grade, under probation. After a certain period of good conduct they may be advanced to the upper-first grade. For various reasons they may be reduced to the lowest, or second grade. All inmates not "in hospital" are employed, most of them at manual labor and many at hard labor. The matter of diet is an important element of discipline. That being assumed, it is evident that the diet of the lowest grade should be of the plainest character, but sufficient to maintain health and strength. A reduction to the lowest grade is a form of punishment that may be avoided by any inmate. The diet of the middle grade should be a fair prison-diet, with a few luxuries on holidays. The diet for the highest grade should be better in all respects than for the middle grade. Promotion to the highest grade is a reward and an encouragement of efforts at reformation. Intelligent administration at the Reformatory should secure considerable savings in the matter of supplies.

SCHEDULE NO. V

Society for the Reformation of Juvenile Delinquents (New York) and State Industrial School (Rochester)

	Daily ration.	Supplies for 100 persons for 30 days.
Meat, with bone, including salted meats, fresh and salted fish, and poultry	6 oz.	1,125 lbs.
Flour, to be used in making bread and in cooking (may in part be substituted by corn meal)	12 "	2,250 "
Potatoes	12 "	2,250 "
Milk (one pint = 16 oz.)	8 "	750 qts.
Sugar	2 "	375 lbs.
Butter	1 "	188 "
Rice, hominy or oatmeal	11 "	188 "
Beans or peas (dried)	1½ "	282 "
Coffee (in the berry and roasted)	½ "	94 "

SCHEDULE NO. VI

Western House of Refuge for Women (Albion) and House of Refuge for Women (Hudson)

	Daily ration.	Supplies for 100 persons for 30 days.
Meat, with bone, including salted meats, fresh and salted fish, and poultry	6 oz.	1,125 lbs.
Flour, to be used in making bread and in cooking (may in part be substituted by corn meal and macaroni)	12 "	2,250 "
Potatoes	12 "	2,250 "
Milk (one pint = 16 oz.)	8 "	750 qts.
Sugar	2 "	375 lbs.
Butter	2 "	375 "
Rice, hominy or oatmeal	2 "	375 "
Beans or peas (dried)	1½ "	282 "
Coffee (in the berry and roasted)	½ "	94 "
Tea (black)	$\frac{1}{16}$ "	12 "

SCHEDULE NO. VII

New York Custodial Asylum for Feeble-minded Women (Newark) and Rome State Custodial Asylum for Unteachable Idiots

	Daily ration.	Supplies for 100 persons for 30 days.
Meat, with bone, including salted meats, fresh and salted fish, and poultry	6 oz.	1,125 lbs.
Flour, to be used in making bread and in cooking (may in part be substituted by corn meal and macaroni)	12 "	2,250 "
Potatoes	12 "	2,250 "
Milk (one pint = 16 oz.)	8 "	750 qts.
Eggs (one egg = 2 oz.)	2 "	250 doz.
Sugar	2 "	375 lbs.
Butter	2 "	375 "
Cheese	1 "	188 "
Rice, hominy or oatmeal	2 "	375 "
Beans or peas (dried)	1½ "	282 "
Coffee (in the berry and roasted)	½ "	94 "
Tea (black)	⅛ "	24 "

SCHEDULE NO. VIII

New York State Soldiers' and Sailors' Home (Bath)

	Daily ration.	Supplies for 100 persons for 30 days.
Meat, with bone, including salted meats, fresh and salted fish, and poultry	8 oz.	1,500 lbs.
Flour, to be used in making bread and in cooking (may in part be substituted by corn meal and macaroni)	12 "	2,250 "
Potatoes	12 "	2,250 "
Milk (one pint = 16 oz.)	8 "	750 qts.
Eggs (one egg = 2 oz.)	2 "	250 doz.
Sugar	2 "	375 lbs.
Butter	2 "	375 "
Cheese	1 "	188 "
Rice, hominy or oatmeal	2 "	375 "
Beans or peas (dried)	2 "	375 "
Coffee (in the berry and roasted)	1 "	188 "
Tea (black)	$\frac{1}{16}$ "	12 "

In addition to the schedules presented, my study of the questions involved leads me to formulate the following recommendations:

I. That the schedules for each institution be taken as representing the maximum of cost of supplies; but that they be carried out with such modifications and substitutions as different conditions may demand. Supplies available in each institution from farm-products, etc., should be charged to the supply account at their market value.

II. That the requisitions for each month should be made as nearly as possible in accordance with the schedules, deducting supplies on hand and carried over from the preceding month.

III. That the store-keeper should be a person competent to inspect and properly care for the meat-supplies as well as the supplies of groceries, etc., curing and preserving articles when desirable on the score of economy.

IV. In case it should appear that any article or articles in the schedules are in excess of the requirements and that such excess is not needed to make up deficiencies in other articles, the requisitions should be made to conform to the requirements of the institution. On the other hand, when

the quantity of any article or articles is insufficient and the deficiencies can not be met by substitution, the requisitions should be increased. It is, of course, not contemplated that every article in the schedules shall be served every day, and it is not believed that actual deficiencies will often occur.

A competent cook should have general charge of the preparation of food for the entire population of each institution and should be held responsible for proper cooking and for due economy, securing the maximum of nutrition from the supplies provided, with the minimum of loss or waste of material. This I regard as one of the most important of the details of administration.

The warden, or executive head of each institution, should be required to make, at the end of one year, a full report of the working of his schedule of supplies, with such criticisms and suggestions as may seem to him to be proper and useful. This report, carefully studied, will undoubtedly lead to more or less revision of certain of the schedules; and the result of one year's trial may show the advisability of grouping together certain institutions, which may then be done on the basis of actual experience.

XL

ON EATING AND DRINKING

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FROM the early periods of life, when the instincts are satisfied with mother's milk, to the stage of existence when Nature is toned down—perhaps by disorders for which man alone is responsible—and possesses tastes that have been engrafted upon it or developed by cultivation, there is a transition so insensible that the satisfaction of the appetites comes to be regarded as a matter of course; and few, except professed physiologists, have ever stopped to inquire why it is necessary to eat, what it is best to eat and what becomes of the tons of matter taken into the body in a lifetime.

What is the real, physiological object of eating, and what is the nature and cause of the appetite? These questions are now pretty satisfactorily answered by scientific men. The as yet unexplained principle of life, which begins with the fecundated microscopic germ and carries man through the allotted threescore and ten years, developing, from material furnished from without, into the perfected organism, is manifested by a constant process of waste and repair. Every instant of existence is occupied in the discharge from the body of worn-out matter. Asleep or awake, in repose or in activity, in health and in sickness, muscle, bone, cartilage, brain, nerves and every part of the organism are worn out, become effete and are discharged in the excretions. The carbonic acid exhaled from the lungs and general surface, the urea and other excretions separated by the great purifying glands, are all used-up animal matter that is thrown off, and if not replaced, the body would daily diminish in weight by several pounds. In the economy of Nature, as it is impossible

to create out of nothing, so matter can not be destroyed and nothing is ever lost. The vegetable kingdom appropriates or feeds on the waste of animal organisms; and animals in their turn are directly or indirectly nourished by vegetables.

Although one never forgets to breathe, the luxury of pure air is appreciated only when there is danger of being deprived of it. The disagreeable sensations experienced in a vitiated atmosphere, which we attempt to relieve by deep, sighing inspirations, are due to want of oxygen in the blood and not in the lungs; and on the other hand, putting a bellows in the wind-pipe of an animal and supplying air to the system in abundance, he may be made to forget to breathe for minutes. The sighs which are sometimes supposed to indicate dejection or powerful emotion are often to be explained by the fact that from preoccupation or other causes, breathing has not been sufficiently constant and profound. It is easy to understand that the pounds of matter daily separated from the blood and discharged from the body in the form of gas, water or solids must be replaced from without. Loss of gas is supplied by breathing; loss of water by drinking; loss of solids by what is known as food. All these are taken up by the blood to be distributed to every part of the body.

Being thus destined to be continually made over, is it not a point of great practical interest to every one to select good materials for the work? The practical truth of this can not be doubted; but the question arises, whether the appetite can be safely relied upon as a guide in this matter. If the dictates of the appetite are just and proper, there are few with whom they would not meet with cheerful acquiescence. But on the other hand, there are moralists who assume that the natural appetites of man are depraved and sinful; and that the lusts of the flesh must be struggled against and overcome. The latter position is untenable and is a physiological absurdity.

In the first place, there can be no question as regards the necessity of some kind of food; for the appetite expresses a positive want on the part of the system for material with which to supply the worn-out parts. It is also true that under varied conditions the system demands dif-

ferent kinds of food. In the arctic regions animal food, especially fat, is demanded in large quantities; and in the tropics vegetables are more desired. If, under these circumstances, the dictates of the appetite are not obeyed, they are enforced by disturbances in digestion and nutrition. Many think that variety in diet is merely a matter of taste; but the craving for different articles expresses a physiological want; and if the monotony of diet is too great or too prolonged, the natural penalty is scurvy and a host of disorders allied to it. Cooking is a necessary preparation for most of the food used by man; and it is a rule to which there are few exceptions that the most agreeable and savory dishes are the most easily digested. Not only are the dishes in which the natural flavors of the articles are developed and heightened by skilful preparation the most agreeable to the palate, but their nutritive principles are easily acted upon by the digestive juices and are readily absorbed and appropriated; while the mongrel soup and the tasteless rehash offend the gustatory sense and refuse to nourish the body. Misdirected ingenuity may conceal the flavor of bad material or impart a certain "goût" to a dish the basis of which has no flavor at all; but such preparations can not be taken often with relish, and the vital forces are never deceived by them.

It is not profitable at the present day to discuss the principles adopted by certain gastronomic sectarians, such as the vegetarians, whose physical condition frequently is the strongest argument against their peculiar views. There is and must always be a natural religion of diet which is accepted by the great mass of mankind. Morbid cravings and fancies concern only the physician. It is safe to trust to the natural tastes and appetites, bearing in mind always that they may be perverted by excesses. Every one, in carefully scrutinizing his experience when he supposes that harm has come from the indulgence of his taste in eating, will recognize that the trouble has generally come from over-indulgence; eating after he has experienced the sense of satisfaction, which is considerably short of satiety.

Finally, there is one great mistake into which dietetists are likely to fall. It is assumed by some that man is simply an animal whose great object in eating and drinking

is to maintain the organism in the most perfect physical condition. It would be unfortunate for progress and civilization were this view to be generally adopted. The large development of the brain, which places man at the head of the animal kingdom, imposes on him extraordinary duties, responsibilities and labors; and these necessarily involve irregularities in living and unusual expedients to sustain temporarily the vital forces. How often has the intellect, in accomplishing a great work, offered up the body as a sacrifice on the altar of common humanity! The world has been most blessed by those who have not been content to pass their lives simply in wearing out and repairing their tissues in the most regular and physiological manner. The lower animals, it is true, never use tea, coffee, tobacco or alcohol. The lower animals never need these stimulants; they can not have the aspirations and cares which belong to the highly developed and exquisitely sensitive nervous system of man.

Leaving the subject of drinking untouched for the present, I shall say a word on what may be called physiological eating. While the regulation of the diet for any single day may be a matter of little moment, the adoption of certain principles of living is of great importance. The subject of dining is the arrangement of a single meal, in which the greatest gustatory enjoyment is obtained for the longest period and with the most reasonable strain on the physical powers, and it does not possess the same general interest but belongs to the poetry of physiological science rather than to the principles of everyday life.

The questions proposed at present are simply, whether the general selection of articles of food is in a reasonable degree in accordance with the present advanced condition of physiological science, and how the mistakes which many must make in this way may be corrected.

In the first place, what are the proper times of the day for eating? It is fortunate for the convenience of different persons that in this a great deal of latitude is allowable. As a rule in this country a substantial meal is taken soon after rising. In some other countries this is seldom if ever done. A cup of black coffee and a bit of bread form the real breakfast of a Frenchman; and the first substantial meal is taken five or six hours after. Frenchmen who

become domesticated in this country usually fall into our way of taking breakfast and find that it answers as well as their own; and Americans who live in France are apt in the same way to adopt the custom of the country. In the city of New York a light lunch is taken in the middle of the day; the hour for dining is about seven; and nothing is taken after that time. In other cities and in smaller places the principal meal is at one, two or three in the afternoon, and a light meal is taken at six or seven. The only physiological requirement is that for about an hour in the day, after the greatest quantity of food has been taken, there should be a certain degree of tranquillity of the nervous and muscular systems.

Breakfast is a meal that generally gives little trouble as regards its digestion, for two reasons: In the first place the quantity of material to be fitted for absorption is generally not large, and the ordinary breakfasts taken in this country are composed of articles that are easily disposed of. In the second place, one does not expect breakfast to disturb digestion and thinks but little of it after it has been taken.

Most persons can not pass the ten or eleven hours from breakfast to dinner without some light nourishment in the middle of the day. Lunch—though it has been called a reflection on the breakfast and an insult to the dinner—should be taken by those who feel they require it. It should be composed, however, of a small quantity of easily digestible material; for the digestive organs of the adult should not be called upon for serious labor more than twice in twenty-four hours. The principal meal of the day is a serious matter. If taken after the greatest part of the day's work is done, it is naturally followed by a condition of repose; but the prospect of this is likely to lead to the habit of relying too much on dinner, eating no lunch and but a nominal breakfast. This makes the dinner too heavy. It leads to inordinate indulgence at that time and throws most of the work of digestion into a single period. Literary men and those who have to work at night find that this sort of life will not answer. The labor of digestion must be more distributed. If dinner is taken in the middle of the day, it is generally found inconvenient to eat too much; and this hour has a certain

advantage arising from the necessity of some mental or physical exertion some time after the principal meal.

What kind and variety of food does man require? It is well known that the system needs nitrogenous or albuminous substances, such as the gluten of vegetables, albumins and lean meat; non-nitrogenous substances, such as starch, sugar and fat; and inorganic saline matters, such as common salt, phosphates, etc. Although the digestive system of man is between that of the herbivora and of the carnivora, it resembles the latter more than the former. Nevertheless, a mixed diet is most favorable to healthy nutrition; and all recognize the necessity of considerable variety in such diet.

Meat may properly be taken at the morning meal. It may not be digested so quickly as some starchy substances; but as a rule it is digested easily, and it certainly satisfies the system and carries us farther in our work than do vegetables alone. At this time meat should be taken in a palatable and easily digestible form; either stewed, with the nutrient juices saved in the sauces and the aromatic principles developed by heat, or better than all, broiled, for here the juices are retained in the tissue. Above all avoid the abomination of frying fresh meat. A fresh animal tissue which has soaked up a mass of seething fat is not in a proper condition to be taken into the stomach. Salted articles, which are generally so hardened that they will not readily absorb the fat, fish and articles which are exposed for but a short time to the very high temperature, may be cooked in this way, but never, good fresh meat.

Meat should by no means constitute the largest part of a physiological breakfast. As this is very often the staple of the dinner, it is desirable to eat a considerable quantity of starchy and fatty matters in the morning. Bread in its various forms, butter and potato are important aids to proper nutrition. The breads should be thoroughly baked and light; for in this form the starch is most easily acted upon by the digestive fluids, which do not readily change raw starch into sugar, the form it must take before it can be absorbed; and the light, porous character of good bread allows it to be easily infiltrated with the saliva and the other juices. Bread likewise furnishes

gluten and is of itself capable of supporting life when too much of this nitrogenous substance has not been removed in making the finer grades of flour. For the same reason the starch in the potato should be thoroughly cooked.

A considerable variety is demanded, not only by the taste, but actually by the nutrition. All the different meats, fresh and salt, poultry, fish of various kinds and eggs may be used. Eggs contain albumins and in the yolk is a large quantity of fat. They are highly nutritious and easily digested; and common usage is correct in placing them in the front rank as articles for the morning meal. Finally, unless warned by the system to the contrary, take in the morning tea or coffee. These are stimulants which have all the beneficial effects belonging to articles of this class, with no unpleasant reaction. As has been demonstrated again and again, by actual experiment, tea and coffee retard the waste of the tissues of the body and enable us to do a given amount of work with less material in the shape of solid food. The physiological effects of these two articles are nearly identical.

A day begun in the way here recommended gives us the best preparation for the labors and trial that we may encounter and is in entire accordance with the teachings of science. If all knew how much of that which is disagreeable depends on the physical condition, they would take more pains to begin each day in the proper manner.

NOTE.—This article was to be one of a number on "Eating and Drinking," but the series was not completed.

XLI

PHYSIOLOGICAL GASTRONOMY

Published in "The Round Table" in 1867.

NO. I.—INTRODUCTORY AND EXPLANATORY

THE human race, even that portion of it which forms this great and progressive nation, is subject to the general law that something can not be created out of nothing. Undoubtedly, our go-ahead people would make the endeavor to work their physiological machinery without fuel were not such vain attempts checked at the outset by penalties as severe as they are inevitable. If a vote were to be taken at the Stock Exchange or the Chamber of Commerce on the question of the practical utility of devoting a number of the hours of the day to eating, drinking and sleeping, a party would probably be found in favor of repealing all the laws of Nature which bear on this question; and many would like to amend the constitution of man so as to do away with the necessity for repose and nourishment. But the constituents of the body will not submit to such treatment. The expenditures of the human organism amount to several pounds in the twenty-four hours; and the material thus lost must be supplied from the external world. The loss sustained in the exhalation of carbonic acid from the lungs must be supplied by the introduction of oxygen and carbon; the loss of water must be made up by drink, and of solids, by taking solid food. These requirements can never be successfully resisted; and science teaches that we can accomplish the most work by conforming to them as closely as possible.

In the more mature nations of Europe, where there is a large class of society without what we call occupation, the wants of the system are more carefully considered than here. The material, which exists in such abundance

in this country, is there more nearly approximated in quantity to the actual wants of the people. In many parts of Europe it is necessary to make use of every particle of food; and we usually find the science of cookery carried to the highest point where this necessity is most keenly felt. If the prices of food in the great cities of this country should remain long at the present rates, there must be a great improvement in the art of cookery. At the tables of most of the first-class hotels managed on the American plan, there is much more food than can possibly be consumed by the guests, and most of the excess is wasted. Many entire dishes pass from the table untouched; and the idea of eating through the bill of fare is absurd. It is by no means an exaggerated estimate to assume that fully one-half of the nutritious matter cooked in hotels is wasted; and the loss is nearly as great in many private families. This may be a trite observation; but it is none the less important, in view of the causes which lie at the bottom of this needless waste and the simple way in which it can be remedied. As a rule to which there are few exceptions, wasteful cookery is bad cookery. Compare, for example, the so-called elaborate "made dishes," with high-sounding French names, served at hotels, with the same dishes served at a good private dinner or a dinner at a good restaurant. In the one instance, the material used as the basis of the dish is seethed for a few moments in a universal gravy, with perhaps a dash of special flavoring, and then put upon the table a half-hour before any attempt will be made to eat it, in what chemists would call an evaporating dish, by which it is more or less desiccated, the volatile flavoring matters being thus lost; or, owing to the high price of alcohol, it becomes refrigerated to a point where it is neither hot nor cold. In the other instance, when the cook expects his dish to be eaten, the peculiar flavors of the meat are carefully developed and heightened by skilfully prepared and harmonized sauces; and it is served at the proper time and in proper condition. The remedy lies in requiring of cooks some knowledge of the culinary art and in educating the mass of the people to such a point that they will generally be able to recognize good cooking.

To develop a class of good cooks in this country seems

almost hopeless so long as there is such a demand for what is called plain cooking. Plain cooking is really one of the most difficult, if not the most difficult branch of the art. "On devient cuisinier, mais on nait, rôtisseur," said Brillat-Savarin. When we consider from a chemical point of view the changes which can be effected in meats simply by the proper application of heat, we can appreciate the delicate operations necessary in plain roasting or broiling. For example, in roasting beef, assuming that the material is good, the delicate flavors which characterize the skilfully cooked piece are developed in the meat itself. The myosin, or substance which forms the greatest part of the muscular tissue, becomes changed in its consistence and develops certain peculiar and characteristic aromatic principles. These are lost if the heat is too intense or too long continued, and they are not formed if the cooking is insufficient. The odorous exhalations from badly cooked meat are simply so much taken from the flavor which it should have when served. To those fond of coffee the odors given off when the berry is roasted are very agreeable; but it would be better if they could be retained and the volatile principles extracted by the boiling water when the coffee is made. It is the same with roasted or broiled meats. One of the most certain evidences of bad housekeeping is the penetration of the odors from the kitchen to every part of the house; and when the bill of fare is announced in this manner, a bad dinner is almost sure to follow. Another item in plain cookery, which will be taken up more fully in another article, is the making of soups, particularly clear soups. A good clear soup contains nearly all the nutrient and empyreumatic constituents of the meat and is difficult to prepare; for here, as in roasting, the best flavors are developed in the cooking and are not added ready-made. In spite of these facts, which are not only well known to all good livers but are demonstrable scientifically, we venture to say that most housekeepers would be astonished if told that their cooks, who may make no pretension to elaborate French cooking but profess only plain dishes, are ignorant of the first principles of the culinary art. Nevertheless this is the fact; and usually when cooks in private families do anything well, it is an accident. The ordinary definition of

a good, plain cook is one who can make soup, roast, boil and broil. The soup generally is made by extracting the proteids from the meat and so effectually coagulating them that it can never be clarified; and both the extract and the bouilli are bad. In the roast, the meat is tasteless and of a uniform drab color; or if you like it rare, it is burned on the exterior and the rest is raw. Broiling is done upon the same principle; and boiled meats have the nutrient matter thoroughly removed. This picture is not very flattering to American housekeepers; but all who have given any reflection to this subject know that it applies to more than half the cooks in this country; and this state of things will continue so long as a distinction is made between plain and fine cooking, and especially so long as housekeepers refuse to educate themselves so as to know when food is well prepared.

On broad scientific grounds, I propose to defend and advocate good living, in the old and in the young, in men and in women. In the old, good living is especially necessary; for as a rule we work in this country so long as life lasts; and even when the system begins to fail in many ways, digestion generally is not sensibly impaired. The practical physician knows that there are many disorders which do not affect well-fed constitutions, while moderate good living keeps the system in the best condition to resist disease, provided the powers are not abused. In the young, the development of the body demands an abundant supply of good, nutritive material. A full-grown, active man must take a goodly quantity of food in an agreeable form, otherwise he is likely to break down when required to perform extra labor, either mental or physical. One of the evils of over-eating or drinking is impairment of the digestive organs so that the proper quantity of nourishment can not be assimilated. Fashionably educated women should live well in order to repair, if possible, the damages which their constitutions have suffered, perhaps, from the long diet of hybrid stews, pasty rice, bread without butter, etc., which they may have endured at boarding-schools. These facts appeal at once to the common sense of every one and are supported by scientific observations.

It is only within the last few years that much has been

learned by physiologists concerning the metamorphosis of tissue. Since 1823, when two eminent French physiological chemists, Prevost and Dumas, demonstrated that one of the most important of the excrementitious matters is formed in the general system and not in the kidneys, the subject of waste and repair of the body has been very closely studied. It has been found that the body, in a condition of perfect health, throws off a quantity of carbon and nitrogen, united with other less important elements, which can be supplied only by a liberal diet. This discharge of worn-out matter is not entirely dependent on the quantity of food taken; and if the supply of new material is insufficient, for a certain time the body will lose in weight and in capacity for labor. But this can not go on indefinitely. After a time the vital powers become reduced so that the discharge of effete matters is made to correspond with the ingesta; but then the system is by no means at the standard of perfect health, although there may be no actual disease. Under the ordinary conditions of life and in persons of easy circumstances, the only effect of this deterioration is incapacity for severe or prolonged mental or physical exertion and generally a deficiency in the power of resisting disease; but the physiological effects are most strikingly exemplified when a definite amount of labor is exacted, as in soldiers during severe campaigns. Under these circumstances insufficient or improper nourishment produces rapid emaciation and leads to serious diseases. In the reports of sick during the late war it was always found that privates were much more frequently affected with disease than officers; a fact which the medical officers of the army attributed to the better hygienic condition of officers in regard to quantity and quality of food. It is a practical fact, important to be remembered by every one, that exercise, both mental and physical, increases the activity of the destructive changes of the organism, as is shown by an increase in the quantity of effete matters discharged; and that consequently the demand for nutriment becomes proportionally greater.

In the present state of physiological science as regards digestion, it is well known that a slight excess of food is easily disposed of; while it is evident that a deficiency must reduce the vital powers. The processes of diges-

tion, absorption and assimilation of nutrient matters are slow and regular, occupying several hours. While this is going on, the matters are passing slowly along the intestinal tract, and part of the excess over that actually required by the system passes through and is discharged in a partially digested state. When a large quantity of food has been taken, the demands of the organism are satisfied for a longer period than if the quantity had been smaller, and thus the supply is to a certain extent regulated by the appetite; and again, the quantity of matter absorbed is limited by the time occupied in the passage of the alimentary mass along the intestine. These facts show that no great harm can result from occasionally taking too much food; but if this is done repeatedly, and especially if the proportion of fats, sugar and starch is considerable, obesity is the almost inevitable result. The very ingenious and instructive pamphlet of Mr. Banting, which has been so popular, especially among persons afflicted with obesity, presents facts which have long been known to physiologists. Starch, sugar and fats are readily digested and absorbed in the small intestine; and it has been shown that a diet composed largely of these substances is most favorable to the deposition of adipose tissue. The ingestion of large quantities of liquids, also, seems to favor this process. As exercise increases the losses of the body by excretion, it is evident that when the quantity of food habitually taken is large, a certain amount of exercise is necessary to keep the organism in a healthy condition. Those accustomed to continuous mental exertion, however, must know that this also increases the activity of tissue-metamorphosis; and frequently the literary man of sedentary habits requires nearly as much solid food as the day-laborer.

It is to be regretted that facts such as these are not more generally appreciated by the educated public. Of all the natural sciences, physiology is the one which should be most thoroughly popularized. Facts are likely to be dry and uninteresting to the people when their applications to everyday life are not made apparent. Certainly it is of quite as much practical utility to know what modern science teaches in regard to eating and drinking as to smatter a little in astronomy, chemistry or natural history.

Scientific dilettantes are very much interested in the numberless varieties of animal life which have lately been discovered in the Amazon, but would be troubled to say what becomes of one of these fish when exposed to the action of the digestive fluids—a question of much more practical importance.

If educated persons were to devote a little time to the study of modern physiology, they would find many very agreeable truths. An experienced diner-out knows that a poor dinner, while it offends his educated gustatory sense, may severely tax his digestive powers. On the other hand, a well-ordered dinner will produce no distress, although the quantity of food taken may be considerable. The cause of the difference is that one is cooked, served and eaten physiologically, while in the other, important physiological laws are violated. He would find, also, that the odors which make the water come in the mouth promotes the secretion of the gastric juice; that digestion is favored by tranquillity of body and mind during and immediately after a meal; that nothing improves this function so much as agreeable society and the actual gustatory enjoyment of food; and, best of all, that the appetite, when not depraved by excesses, is a reliable guide as to the quantity and kind of food to be taken. This last is an important consideration; and I do not make this assertion in regard to the appetite lightly or without a positive scientific basis.

What is ordinarily known as the appetite expresses a necessity on the part of the system for food. Thirst expresses a demand for water, and the indefinite sense, called sometimes the respiratory sense, expresses the want of air. When either of these wants is supplied, the corresponding sensation ceases. Thirst may be alleviated by injecting water into the veins; but solid food requires elaborate preparation by digestion, and hunger can be relieved only by eating. As regards the proper quantity of food, the appetite is a safe guide, if its dictates are scrupulously followed. Few persons actually wish to eat too much; and if the stomach becomes overloaded, it is generally because eating is continued after the appetite has been satisfied.

In regard to the kind of food, the taste is usually a

proper guide. There is no fact better known to physiologists than that the organism demands a varied diet. Not only is it hurtful to restrict the diet to salt meats and dry bread, as is often done in armies and at sea, but there must be considerable variety, even when we have fresh meats and vegetables in abundance. If the diet is very monotonous, the disorders in nutrition are well marked. Scurvy, with its varied phenomena, is the result. But feed a scorbutic patient only for a few days with precisely what his appetite craves, such as pickles, onions, fresh meat and what are known as antiscorbutics, and the immediate improvement is often marvellous. In the winter fat meats and the heavier articles of food are most consumed, while in summer light, succulent vegetables are more freely used. In the arctic regions the quantity of meat, especially fat meat, which is consumed is almost inconceivable; while in the tropics these articles are taken in small quantity. This difference in the appetite expresses different demands on the part of the system. When the body is exposed to intense cold the nutritive processes are exaggerated in order to keep up the animal temperature, and the appetite is correspondingly increased.

When we attempt to explain why the system demands that variety in diet which is known to be so essential to perfect health, science is at fault. All that physiologists have done has been to demonstrate by experiments upon animals—and some have repeated these experiments on their own persons—the simple facts just stated; but much may be done in the way of explanation of the fact that skilfully prepared dishes are most easily digested and are most nutritious. If the chemist wishes to extract from meats the greatest possible quantity of nutritive animal matters without employing powerful solvents, he will employ much the same method that a good cook would use in making a soup. If a physiologist wishes to excite the secretion of the digestive fluids, he will succeed best by presenting to the gustatory nerves meats in which the peculiar aromatic flavors have been highly developed. With morbid tastes we have nothing to do, for these concern only the physician; but the natural tastes, which may be cultivated without being perverted, are to a great extent an indication of the wants of the system. It is com-

forting to reflect that these inclinations, which it is often difficult to resist, may usually be followed with safety.

There is undoubtedly such a thing as physiological gastronomy. Man is not a machine designed for purely physical labor, the highest object of whose existence is to keep the functions which he possesses, in common with the inferior animals, in the best possible condition. The great brain with which he has been endowed gives him extraordinary responsibilities and aspirations. He is exposed to unusual labors, which involve irregularities in living and necessitate many expedients by which the forces may be temporarily sustained for the performance of some work which may greatly advance the interests of humanity. The physical infirmities which are so frequently attached to men of great intellect are often to be looked upon as sacrifices rather than vices; and such men receive most charity from those who are best able to appreciate their works. As an offset to these requirements, man has been unusually endowed with the faculty of deriving pleasure through the senses, especially when these have been highly cultivated. In a perfect dinner everything should progress harmoniously like the movements of a symphony; but this is subject to certain scientific laws. Confessing my inability to treat of dining from a purely gastronomic point of view, I propose in a few articles to consider this subject physiologically. There is a certain routine in dining which is generally accepted by gastronomes in the centres of civilization; and it may be interesting to note how far this is in accordance with known physiological laws.

NO. II.—THE FIRST STEP IN DINING

An attempt on the part of scientific men to modify to any considerable extent the habits and customs of refined and educated persons as regards dining would be revolutionary and probably hopeless. We are forced to take society, in this respect, as we find it; and all that can reasonably be expected is to reform certain faults in eating and cooking that are opposed to sound physiology, and to point out what is good and what is bad in the selection, preparation and serving of the various articles that are habitually consumed at the principal meal of the day. It

will be easily recognized that the first important step is a proper selection of material. Practical men who buy and sell articles used as food hold decided and, in the main, correct opinions as to good and bad marketing; and experience has taught them certain general principles that are almost always in accordance with scientific laws. There are many different kinds of food that must be purchased every day; and the manner of selecting these articles, so as to secure them of the best quality, should be known to all, especially as the best may in many instances be bought at the price of articles of inferior quality. Of course no one can expect to become proficient in marketing without that ready tact which is acquired only by experience; but science teaches certain facts that can readily be appreciated.

It may seem a matter of little practical importance to select meats from which the aromatic and nutritive matters are to be extracted in the form of soups; but careful investigation of this subject has shown that this view is erroneous. A short time ago there was an exhaustive discussion in the "Imperial and Central Society of Agriculture" in France, concerning the alimentary qualities of butcher's meat; and Chevreul, who is very high authority on this subject, stated that the good quality of beef is indicated by the excellence of the soup, as regards aroma and nutritive value. It is well known that a good soup is one of the most difficult things to make in the whole range of meat-cookery. Although much depends on the cook, much likewise depends on the quality of the material. Soup need not, of course, be made from the most delicate parts of the animal; but the general quality of the meat must be good. To secure a good piece of beef for roasting or broiling, the animal should be full grown, seven to nine years old, and well, though not excessively fattened. Having thus provided good material, it is not difficult with proper care to extract the soluble nutritive and flavoring principles and make good soup; but it is impossible to extract these constituents and have remaining a well-flavored, nutritious piece of meat. In a good piece of boiled meat, these principles are retained. The article known to housekeepers as "stock" contains the substances necessary as the basis of all good meat-soups.

Suppose, for example, we have a piece of lean meat from the leg, the neck, or any of the coarser parts of beef, veal or mutton, and it is desired to extract from this the nutrient and flavoring principles that are soluble in water, without employing acids or other strong solvents, by which these would be more or less modified; the following, then, would be the proper mode of procedure: The lean of the meat, cut into small pieces, is put into a vessel containing a little cold water, just enough to cover it, and gently warmed through; this will soak and swell up the muscular tissue, while the gentle heat liquefies the fat without coagulating the albumin or hardening the muscular fibre. Enough cold water is then added to extract all the soluble matters—about a quart of water to a pound of meat—and the temperature is raised very gradually to near the boiling point. It is necessary to keep it at this temperature for three to six hours, allowing it to gently simmer, but never to boil. In this way certain matters will be extracted and held in solution, while others will rise to the top in the form of a scum. By this process the fibrous connective tissue of the meat is dissolved and changed into gelatin; a part of the various soluble salts and organic matters, chlorides, phosphates, hydrochlorates of soda and potassa, lactic acid, albumins, coloring matter, creatin, etc., are dissolved in the cold water; and the prolonged application of moderate heat causes the organic principle of the muscular fibre (myosin) to abandon a certain portion of its substance, which is thus rendered soluble. The heat likewise melts the fat, dissolves and forms gelatin out of the fat-vesicles, and coagulates the albumin, these rising to the top in the form of a scum, which should be constantly removed. Another and an important change is effected by the prolonged heat. All the true organic substances are capable of developing certain volatile odorous or empyreumatic principles which give the high flavor to cooked meats. These are, of course, developed in the process of making stock; and it is important not to allow the liquid to boil actively, when a large portion would be lost.

By the above process only a portion of the nutritive parts of the meat is extracted, and the bouilli retains a certain quantity of nourishment in its muscular fibre. If

Liebig's method is employed, which consists mainly in the addition of a little hydrochloric acid, nearly the whole of the muscular substance is dissolved; but this process is used only in making concentrated meat-extracts for invalids.

There is one point in the making of soups, of much scientific and practical interest, particularly in the preparation of food for public institutions. It has been found that bones boiled for a long time, either before or after the earthy matter has been extracted by dilute hydrochloric acid, are transformed into gelatin, a substance that was supposed at one time to be highly nutritious. It has, however, been ascertained that gelatin, although it gives consistence to soup, is without flavor and has hardly any nutritive value. The idea that gelatin soups, flavored by the addition of extraneous matter, could be used with advantage in charitable institutions was at one time quite prevalent in France. Volumes have been written on this subject; and some French physiologists, with characteristic enthusiasm, asserted that every button or bone-handled knife was so much nourishment stolen from the poor. So vigorously was this question agitated at one time that it was proposed to introduce bone-soups in the public institutions of Paris. This was, indeed, done to a certain extent; but the victims of the experiment soon rebelled against the deceit which was thus practised on their stomachs, and the general dissatisfaction and wide differences in the opinions of scientific men on the subject rendered it necessary to submit the matter to experimental inquiry. Happily, with the exception of a few experiments which those engaged in the question made on their own persons, the observations were transferred from men to dogs; and the commission appointed by the French Academy, with the great physiologist, Magendie, at its head, after a delay of ten years, reported in substance that gelatin possessed hardly any nutritive value. This commission is historical under the name of the "Gelatin Commission"; and its report, which was made in 1841, is universally regarded as conclusive.

If we examine critically the process employed by good cooks in making stock, we shall see that the basis of their operations is sound. The rule is first to put the meat,

cut in pieces about the size of an egg, into a little cold water; then to add a little bacon, salt, spices, a few onions and other vegetables, with usually a little butter in the bottom of the pot so as to regulate the temperature of the whole. The accessories are added at this time so as to extract their full flavor. After this has been gently heated, the full quantity of water is added, the whole is brought to a simmer, and kept a little below the boiling point for a number of hours, the scum being carefully removed as it rises. It is then carefully strained through a fine cloth or a hair-sieve. It is never boiled briskly, for then a part of the volatile flavoring principle is lost. When put aside for use, it is allowed to cool and gelatinize quickly.

It is now generally admitted that every meal that can be dignified by the name of dinner begins with soup, unless, as is the habit of some on great occasions, the digestive organs are awakened by a few raw oysters. By using stock in proper proportions and adding different articles, most of the great variety of soups may be made. A clear soup, which is composed mainly of stock, may be taken as the type of all soups. How far, now, does the taking of a soup of this kind at the beginning of a meal coincide with what is known of the physiology of digestion?

The material thus introduced is highly flavored, thoroughly cooked, and probably it is as readily digestible as in any form that could be devised. The actual quantity of nutriment taken is not great; but it is in the most palatable and soluble form and undoubtedly excites, in a purely physiological manner, the secretion of gastric juice. Digestion in the stomach always progresses slowly and gradually, the alimentary matters are constantly being liquefied and absorbed, and food should never be introduced too rapidly. The empyreumatic principles formed from meat are among the most powerful exciters of the secretion of gastric juice; and it has repeatedly been shown by experiments on the lower animals that when secretion is excited in the stomach, the fluids in the small intestines, where the final and most important processes of digestion take place, are likewise poured out. Thus, the ingestion of a light, well-flavored soup prepares the digestive organs for the reception of the more solid articles of food. However, as regards digestion there is a great deal in the habit

of eating. Many do not habitually take soup; and others, who are accustomed to it, experience trouble in digestion if soup is omitted.

It is evident, therefore, that there are good physiological reasons why the usage of beginning a dinner with soup should be so common. This is true of almost every widespread custom in eating. Science more frequently explains than controverts the habits of men in living. But this manner of making and taking soups is applicable only to those in affluent or easy circumstances, when the question of expense is not of much importance. Soup is an excellent article of diet for those who live moderately, and even for the lower classes. When it is an object to save expense it should be made somewhat differently. By having the meat in large pieces this may be eaten; and with a little preparation it is quite palatable. Though the meat does not retain its full value, nothing is lost, for what is extracted is saved in the soup. The soup may then be served with vegetables, and the meat and bacon by themselves. An occasional meal of this kind contributes to the variety of diet which is essential to good health; and it presents the alimentary principles in a condition favorable to assimilation. A cheap meal prepared on these principles should enter more frequently into the diet of the laboring classes, who too often take their food cold and unsavory, when with care and no more expense they could be much better fed.

An interesting question to the practical philanthropist is the alimentation of hospitals, prisons and other public institutions. One of the most important articles of diet in such institutions is soup; and there is no good reason why it should not be properly made. It is to be feared that in this matter the authorities in this country do not take pains to follow the teachings of science as they do abroad, particularly in France. The following formula used for making soup for the Parisian hospitals might with advantage be generally adopted in this country, as it is the result of the most exact scientific inquiry and has stood the test of long experience.

The capacity of the kettles used should never exceed twenty gallons, as in larger vessels the pressure on the lower strata of the liquid causes the temperature to rise too

high, and the aroma is thereby in part destroyed. The proportions for twenty gallons of stock are as follows:

Water	20 gallons.
Meat, weighed with the bones	68 lbs. 10 oz.
Vegetables	13 lbs. 10 oz.
Salt (chloride of sodium)	1 lb. $12\frac{3}{4}$ oz.
Burnt onions	$7\frac{3}{4}$ oz.

The meat should be cut off from the bones and tied with strong cord into packages of nine or ten pounds each. The bones should be broken up and placed in the bottom of the kettle. The packages of meat should then be placed upon a grating or perforated false bottom, above the bones. Twenty gallons of cold water are then poured in, the whole is raised to the boiling point and the scum is removed as it forms. It is kept gently boiling for two hours, during which time it is constantly skimmed. Between the first and second hours, when the skimming is nearly completed, the vegetables with the burnt onions are introduced inclosed in a net bag. A gentle ebullition is then maintained for four or five hours. The fire is then extinguished, and after about an hour the vegetables, the meat and the bouillon are taken out. When the latter is to be used, the congealed fat is taken from the top, and the bouillon is mixed with about the same quantity of water and heated to make the soup.

I venture the opinion that this is a better soup than that prepared in most of the hospitals in this country, and not more expensive or difficult to make. Those having charge of institutions of this kind should endeavor to adopt all improvements in hospital management, particularly as regards alimentation; and I am sure the poor would be benefited by a trial of the French method of making soup.

To return to soups as articles of luxury, there is no doubt that a good dinner should begin with some article containing a moderate proportion of nutritive matter in an easily digestible form, but above all, aromatic principles calculated to excite the normal secretion of the digestive juices. For this purpose nothing answers so well as a well-made soup, not heavy, but light and palatable; and in its preparation every cook should follow the principle to extract as much nutriment and develop as much

aroma from the meat as possible. To dine scientifically it is proper to begin fairly with the soup and let this be the first article which makes an impression on the stomach.

In these remarks I do not intend to make any strictures on the practice of taking a few raw oysters or clams at the beginning of a dinner, which is not at all uncommon. These mollusks when raw are as easily digested as anything that can be taken into the stomach. They do not absorb the juices, and beyond the gustatory impression which they make, appear to have no effect whatsoever. Taking them before soup is a question of taste.

The dinner is now fairly begun; and the beginning is nearly always the most delicate and difficult part of every undertaking. In following out the plan of these articles, I propose to consider the succeeding steps, which will come naturally and easily now that the first has been taken.

NO. III.—FISH

As I propose in these articles to follow the natural course of a dinner, the next subject for consideration is fish. It is customary, in all dinners in which completeness and elegance are considered, to follow the soup with a service of some kind of fish. This custom, like that of taking soup at the beginning of a dinner, is so universal that it becomes an important question to determine whether it is based upon physiological laws or is simply a matter of taste. In treating this question there are several points to be considered: In the first place, the necessity of variety in alimentation is so imperative that man is benefited by drawing material for his sustenance from all sources that furnish it in a form in which it is agreeable to the palate and can be assimilated without difficulty. From this point of view, the different kinds of edible fish must be regarded as among the most important articles of food. Though not so nutritious as meats, they contain a large quantity of reparative matter; and that they are capable of sustaining life, when taken as almost the sole article of diet, is illustrated in entire communities that are able to obtain hardly any other kind of food for a considerable part of the year. On the other

hand, assuming that we are able to procure the richer articles of animal food, is it desirable to use fish to any great extent; and if it is used, when and how should it be taken?

All scientific men who have given any thought to the subject of alimentation must agree that fish is an important article of food, even when meats are to be had in abundance. Beside contributing to variety in animal diet, it frequently seems peculiarly well suited to the digestive powers of certain persons, presenting an adequate quantity of nourishment in a form in which it is disposed of with great facility. As a rule the flesh of fish is tender, the fibres are loosely held together by intervening tissue, and its whole substance contains much more water and a relatively smaller proportion of solid nutriment than the flesh of warm-blooded animals. It is thus admirable for a light meal, such as breakfast. Nothing could be more healthful than good fresh fish at this time; and when in season, it takes the place very well of meats, which are more difficult of digestion and more costly.

There are many good reasons why fish should be taken at dinner and why it should be served between the soup and the meats. At an elaborate dinner, those with good health and fair appetite are often in danger of eating more than the system needs or can easily assimilate. If one course consists of fish properly cooked and served, this may take the place of heavier articles. If taken at all, it should be when its flavor can be best appreciated. It is apparent to every one that the only place for fish is after the soup. One might as well expect to enjoy the bouquet of a fine Bordeaux immediately after a draught of whisky as to appreciate the flavor of a good fish after eating largely of highly seasoned meats.

There are few exceptions to the general rule that fish should be cooked and eaten as soon as possible after being taken from the water. Most of the finer fish are not tough; and the object should be to have them on the table with the flesh as firm as possible, and before it has had time to undergo some of the changes which take place in all organic matter after death. Immediately after death, the flesh of the warm-blooded animals is tough and not well flavored; and the first changes which it undergoes

render it more tender and develop its flavor. In fish, any change which takes place after death usually is detrimental to the flavor. The oils, which are more or less infiltrated in the muscular substance, are the first to change and give rise to volatile products, offensive alike to the smell and the taste. The only marked exceptions to this rule are the ray-fish and large soles, the flesh of which is too hard unless kept for a day or two.

In the selection of fish at the market it is easy to determine their freshness. When in the best condition, the shield of the gills is firmly closed, the fins are moist and adhere to the sides, the gills are moist and of a vivid red color and the flesh is firm to the touch. The weight of the fish and its firmness indicate a favorable condition of the muscular tissue; but the color of the gills is the best test of its freshness. When the gills are dark, soft and flabby, it is probable that the animal has been too long out of water. The red color of the blood is due to the presence of oxygen in the blood-corpuscles; and after the blood of any animal has been allowed to stand for some hours it becomes dark, as the oxygen disappears in part and its place is supplied by carbonic acid. If the blood is of a vivid red color, this change has not had time to occur. The appearance of the eyes, also, is much relied upon by good marketers as a test of the freshness of fish. When a fish has been dead and exposed to the air for a long time, the eyes are shrivelled, opaque and sunken; while in a fresh fish they are clear, full and bright.

All fish are in their perfection during the development of the milt or the roe, a short time before they are ready to spawn. Just before or just after spawning, the flesh is softer, there is less fat and the flavor is very much inferior. In the migratory fish, which are caught only during a particular season, we appreciate the flavor much more keenly when they are abundant and in full season than toward the close. The last of the shad are notoriously inferior to those taken at the proper time. This is because the fish have accomplished for the season their generative function and have consequently become thin and tasteless. Fish, like the different kinds of game, to be eaten in perfection, should not be taken out of season.

The enumeration even of the varieties of fish consumed

by the inhabitants of this continent would be an almost endless task. Almost every locality has its fish that are peculiarly prized. In the city of New York, a great variety is presented, as it is the centre which receives luxuries from all places whence transportation of perishable articles is practicable. Of the many excellent fish that are to be obtained in this market, I shall mention but a few. Some of them seem especially suited for dinner, while others are more appropriate for breakfast.

The salmon is considered by many to be the best of all fish for the table. When in season and in perfect condition, not only is it a fish of most delicious flavor, but the delicate rosy color of the flesh makes it a very attractive dish in appearance. I venture to assert that there are few routine grand dinners in this city in which salmon is not introduced when in season; and yet, in such a place, it is one of the most unphysiological dishes that could be devised. It has always seemed out of place to have two soups and two kinds of fish at a dinner, be it never so elaborate. If I were called upon to decide upon the arrangement of a dinner as a physiological problem, the guests would not have the opportunity of choosing between two articles, either in the service of soup or of fish; but would be expected to go through the dinner from the beginning to the end, partaking of every dish, and that without more than reasonably satisfying the appetite or throwing too much labor on the digestive organs. But in case it be deemed necessary to introduce salmon at dinner, it should be under one of two conditions—either that the fish is expected to constitute the chief part of the repast, or some lighter fish is provided for those who wish to partake comfortably of the dishes that are to come after. My reasons for this statement, which may do violence to the gastronomic sensibilities of some, are the following: Of all edible fishes salmon and eels contain the greatest quantity of oleaginous matter. As regards chemical composition, the flesh of salmon is hardly inferior to the meats in the quantity of nutritive material. Although I by no means desire to be understood as opposing the use of any article of diet simply because it contains a large proportion of solid matter and requires a long time for its digestion—for prolonged digestion does

not always indicate difficult digestion—there can be no doubt that an article so solid as salmon should not take the place of the lighter fish in a dinner. The proper place for salmon is at breakfast; when it should be cut into slices and broiled, or for supper, boiled and served cold with salad or mayonnaise. When salmon is plenty and cheap, it may be served at dinner if desired, taking the place of a dish of meat; but it can not be well taken as a prelude to the meats, except by persons of more than ordinary gastronomic powers and very robust digestion.

For the fish-course at dinner the Spanish mackerel, brook-trout, shad, bass, pickerel, yellow-pike, whitefish, kingfish, smelts and many other good fish are proper. Let the fish be perfectly fresh and in season and well cooked and it will not cloy the appetite or trouble the digestive organs. Fish is one of the most difficult articles to cook delicately and well. Perhaps the most desirable way to cook the ordinary large fish is by boiling. It should be put into boiling water which has been well salted. The high temperature of the boiling salt water quickly hardens the exterior, so that the juices do not exude, and the presence of the salt in the water opposes the solution of its nutritive principles. When cooked in this way, however, the flavor should be heightened by sauces, which are made in such infinite variety by good cooks. The natural flavor of the most delicate fish, such as Spanish mackerel or shad, seems to be best developed by boiling. The first shad of the season are usually best appreciated when cooked in this manner and eaten without any highly flavored sauce. Baked fish is very common, but this mode of cooking seems to render both meats and fish tough and hard without developing their peculiar flavors. Physiologists who have devoted any attention to the subject of the preparation of food are quite generally opposed to baking. This mode of cooking is certainly inferior to broiling or roasting, as regards the development of volatile empyreumatic principles from meat.

Fish is one of the few articles that can with advantage be fried. The high temperature to which everything cooked in this way is subjected seems to favor the development of the peculiar flavors of fish. But in frying fish, it should be remembered that the fat should never be

absorbed by the muscular tissue. The lard or fat that is used should be very hot, but of course never scorched; and the articles to be fried should be protected by a coating of batter, crumbs, or flour, so that the fat really does not touch them.

Some of the best fish are caught in immense numbers at certain seasons of the year, and it is necessary to preserve them for future use by drying, salting or pickling. In this form salmon, mackerel and the large trout and whitefish from the inland lakes are brought to the market. No one would think of introducing fish thus preserved as a course at a formal dinner, but they may be used at any meal in the place of other animal food. It becomes an important economical question, therefore, to ascertain whether these articles can properly form any considerable part of the regular diet. Analysis of salted fish, after it has been freshened and prepared for cooking, shows that it has lost much of its nutritive matter and that which remains is modified so that it is hard and indigestible. Salt fish, therefore, can not properly constitute a large portion of the daily food. Taken in small quantity, as "a relish," with more digestible and nutritious articles, it undoubtedly stimulates the secretion of the digestive fluids; but when it is the only animal substance taken, it must be conjoined with an abundance of bread, butter and vegetables, or nutrition becomes impaired. The poor can not depend to any great extent on salt fish, although its cheapness is a great recommendation. In charitable institutions, salt fish may be tolerated one day in the week, but it can not be used as a frequent article of diet. A good salt mackerel broiled makes a fair occasional breakfast; but this alone will not carry a strong man well through the day and is very different in its nutritive value from a fresh fish of the same species. Salt fish, on the whole, is to be avoided, except when taken with other articles that possess more nutritive material and are more easily digested. It is hardly necessary, however, to warn those who are able to procure all kinds of food of this, as the deficiencies in any kind of diet are almost always made up by the consumption of other articles.

Scientific facts would lead us, on the whole, to regard fish as very important in the alimentation of the human

race. In one form or another it may be taken at any meal in the day. If we succeed in propagating and fattening fish as perfectly as we may reasonably hope to at some future time, the breeds may be improved and the flavor heightened by particular kinds of food, so as to render fish-culture an important and a useful art. The " bon vivant," who believes that no dinner is complete without fish in its proper time and place, has some scientific support for this opinion; for nothing but fish can take the place between the soup and the meats. Delicate in flavor, harmless to the appetite, easy of digestion, a fine fish is here in its appropriate place.

NO. IV.—MEATS

Man is neither herbivorous, graminivorous nor frugivorous, but in the widest signification of the term, is omnivorous; and it is not to man's advantage, physiologically or otherwise, to take his food, which he thus draws from all sources, either of inferior quality or badly prepared. Man is likewise a gregarious animal; and when large numbers are packed together, as in great cities, it is necessary that they be fed with care, using all proper nutritive matters and wasting nothing. This can be done only by drawing food from all the subdivisions of the animal and vegetable kingdoms, preparing it by cooking, so as to utilize the greatest possible proportion.

In all large congregations of men, there are some who, from force of circumstances or their own efforts, have risen beyond the ordinary level, many of whom work so long as they live, for further power and advancement. There are weaker spirits who desire simply to maintain what they consider to be their normal position in society; and finally there are others, the most feeble and uncultivated intellectually, whose lives are merely a struggle for existence. It is one of the recognized social duties of the powerful and affluent classes to aid those who, from sickness or other causes, can not feed and clothe themselves; and consequently in all civilized communities we find hospitals and other charitable institutions. All must be fed, and all should have daily a certain quantity of meat. This assertion is not made without sufficient experimental proof. I need not ask the naturalist to describe the teeth and

large intestine, the conformation of which clearly enough indicates that man is made to consume animal as well as vegetable food, but shall simply relate one or two experiments, made on an extended scale, which show that men who live chiefly on vegetables are physically inferior to those who are supplied with meat. In treating of gastronomy from a physiological point of view, one should least of all neglect the subject of alimentation of the poorer classes; and this subject has engaged the attention of some of the most eminent scientific men of the age. In 1841 a company engaged in building a railroad between Paris and Rouen employed in its construction a number of English engineers, who imported workmen from England in addition to the French laborers. As these two classes of laborers worked together, it was found that the French could accomplish only about two-thirds of the work of the English. Recognizing the great differences in the alimentation of the English and the French, the boiled or roasted beef used by the English was finally substituted for the vegetables and weak soups with which the French were almost exclusively nourished; and from the moment that an equality in diet was thus established, the French began to accomplish as much labor as the English. The same thing was illustrated in 1825 in an iron foundry which was established near Paris on the English plan. Here it was found necessary to employ English workmen for certain operations requiring great strength and endurance, which could not be performed by the French; but on feeding the native workmen with meat, it was soon found that they became strong enough to do what was required, and the imported workmen were sent back. It is unnecessary to cite other examples of this fact, which has been illustrated over and over again.

I do not discuss the question of the necessity of meat in the alimentation of man for the purpose of convincing those who can easily obtain what they desire to eat that meat should constitute a considerable part of their diet; for this is an article of food which no one in affluent or even moderate circumstances ever thinks of discarding. But for the poor, animal food is a necessity and not entirely a luxury; and it is cruel and inhuman, viewed from a physiolog-

ical standpoint, to send out from prisons and other public institutions men who are too weak to compete in labor with those who have been properly fed. A proposition made not long ago, by an English physiologist, to reduce the not very abundant fare in British prisons, justly excited the opposition of every one who knew anything about the subject. One of the objects of organized punishment of crime should be to effect reform; and the chances of this must be greatly diminished when prisoners are discharged in the reduced physical condition which results from poor and insufficient food.

The popular and scientific experience of the world, therefore, leads to the conclusion that animal food is an important, if not the most essential element in the nutrition of man. All our instincts, so far as they can be recognized after the modifications which result from habit and education, lead us to regard this as the most solid and reliable of our foods. The usages of all civilized nations recognize meats as the principal articles to be taken at dinner; and this is in entire accordance with scientific experience. It is by no means to be assumed that articles which are acted upon slowly by the digestive fluids are necessarily difficult of digestion. Nature makes provision for a slow and gradual transformation of alimentary matters; and the comparatively tardy digestion of meats is entirely normal, if it can be shown that these are necessary and proper articles of food. Although habit has a large influence on the appetite and digestion, it generally is proper to confine the principal digestive labor in the twenty-four hours to the disposition of a single meal. A person of moderately sedentary habits, accustomed to take a large breakfast and a solid lunch, can not hope to be always a reliable diner. But on the other hand it is not desirable to take all our nourishment at a single meal or to go too long without eating; and especially we should not attack a physiological dinner, which is to be gone through from the beginning to the end, with a ravenous appetite. Too often it happens, when this is the case, that the first articles are taken with avidity, that an abnormally abundant flow of gastric juice follows their introduction into the stomach, and the unhappy victim finds suddenly that his appetite is gone when it is most desired. Under these

circumstances a young, inexperienced and sensitive diner is quite likely to force himself to exceed his appetite; and he must be the possessor of a very vigorous digestion to escape an attack of dyspepsia as the result. The best physical condition for dining is perfect health, after moderate and not unusual exercise, when food has been taken through the day at the usual times and in nearly the usual quantity. With a consciousness that there is nothing after dinner to do but comfortably to digest and assimilate, there is a tranquillity of mind and body which leads to the highest development of the gustatory sense.

The varieties of meats that may be served at dinner and the methods of their preparation are almost infinite and differ in nearly all countries. A Frenchman is astonished and finally overcome by a grand English dinner; and a true Englishman can not dine satisfactorily, even in Paris, without his enormous joints. A happy medium in this regard prevails at the best tables in this country. We are here able to appreciate the plain roast meats of the English as well as the delicate composite dishes of the French.

In the modest dinner which forms part of the daily routine of a great portion of our population, the meats are not necessarily preceded by soups and fish, to say nothing of cold oysters, "bouchées, hors d'œuvres," etc., with the attendant wines, which make their appearance on state occasions. In a previous article I have advocated light soups at the beginning of dinner; or if no soup is taken, a delicate fish may be served in its place. Although this is much a matter of habit, it is more physiological to begin a substantial meal with some light and delicately flavored article than to enter at once upon the most solid food that can be taken. With this exception, the old rule that the order of dishes should always be from the more substantial to the lighter articles is the safest one to follow. There is no danger then that the principal dish of the dinner will be neglected, and the game should always be highly flavored and delicate enough to tempt the appetite, even after partaking liberally of other dishes.

The first important gastronomic point to consider is the selection of meats; but unfortunately marketing can never be done according to definite and invariable rules.

Take, for example, the single item of beef. Beef should be pretty large; but some of the best varieties are small, like the young spayed heifer or the free-martin, which afford the most delicately flavored and the finest grained meat. There are, however, certain principles in feeding and killing that are recognized in the scientific world as necessary to the production of the best and most nutritive meats. With the exception of a few instances in which meats are used some time before they arrive at maturity, and are then justly regarded as luxuries, animals to be used as food should be young but full grown. It is almost unnecessary to add that they should be in perfect health, never having been overworked or affected with disease. The flesh of young heifers that have been raised and fed with care until maturity is considered by some as possessing more sweetness and delicacy of flavor than any other kind of beef; but so far as true excellence of the meat conjoined with the greatest amount of nutritive value is concerned, a young bullock, about seven years old, that has been very moderately worked for a few months and then carefully fattened, affords the best quality of beef. Precocious meats are likely to be soft as well as tender, and they do not possess the richness and the flavor which is so highly developed in the flesh of animals that are in a perfectly normal condition. A rapid development of the soft tissues with an excessive formation of fat generally is the result of over-feeding conjoined with confinement and insufficient exposure to the air and light; and such meats answer as occasional luxuries, but their best qualities as alimentary articles are not developed.

The excellence of mutton depends upon nearly the same conditions. The reputation of English mutton is undoubtedly well deserved; and aside from differences in breeding, it depends on greater advantages in feeding. The sheep in England are not exposed to the great changes in weather which we have in this country; and consequently they have the advantage of light and air during nearly the entire year. The best English mutton is also more carefully fed than ours, and has the advantage, when brought to our markets, of the cool and salt sea-air in the transportation. Excessive formation of fat is not favorable to the development of the best qualities of any kind

of meat; and on this account prize mutton or beef is not necessarily of the best flavor.

Animals should be killed when they have been for some time perfectly quiet and are in the highest physical condition. When they are heated or have been overdriven, the tenderness and flavor of the meat are impaired. The old idea, however, that venison is better when the deer have been hunted to death, is not without some foundation. This mode of death exhausts the vitality of the muscular system, and it has been found that the putrefactive changes begin very early and proceed with great rapidity. In the changes of the muscular tissue immediately preceding putrefaction, some of the most delicate flavoring principles are developed; and these being hastened, the meat arrives at its best condition much sooner than if the animal had been slaughtered in the ordinary way. Animals should fast for at least twenty-four hours before being killed.

Lamb, spring-chickens, young grouse and partridges are examples of young meats which are more delicately flavored than after they have arrived at maturity. The characters of veal are so different from those of beef that it can be regarded almost as a distinct article. Veal requires thorough cooking to develop its aromatic principles; and it is much inferior to good beef in nutritive properties, and, indeed, in every other regard.

It would open a subject too extensive for present discussion were I to attempt to designate the particular kinds of meat and the parts of the animals used as food which are most desirable. An intelligent and honest butcher is the best person to give information on this subject. I have seen a saddle of mutton so fat that it could be cooked only with great difficulty, and the muscular tissue was small in quantity and tasteless; but the legs of the same animal could hardly be excelled in delicacy of flavor. Not many years ago, most good providers selected a sirloin roast of beef, and the few who were aware of the superior excellence of the choice ribs found no difficulty in getting precisely what they desired. This is a single illustration of the changes that have taken place in the views of marketers in regard to the selection of meats; for now nearly all who know how to buy select the "second-cut" ribs.

It would be considered a piece of gross ignorance for any provider to be unaware of the superiority of the porter-house steak over all others; but nearly every one is careful to see that the butcher cuts the steaks with plenty of tenderloin. A good porter-house steak, well broiled, so that all the juices are retained and the full flavor of the meat developed, is one of the most agreeable and nutritious of the meat-dishes; but its excellence does not depend on the size of the tenderloin. The most skilful providers select a fine piece of beef and take the small steaks which have hardly any tenderloin, cut from the loin near the ribs, where the "filet" is small. Steaks from this part have the delicacy of flavor of the rib-roast; and it is well known that the filet is so wanting in richness that it generally is larded or made into a "sauté" with highly flavored articles, in order to make from it a dish of the first order. But as before remarked, on these questions the advice of the butcher should be taken by those whose education in marketing is imperfect. Butchers are generally well-fed, good-natured, enthusiastic in their calling, and they commonly feel a certain degree of interest in those who are willing to make an effort to select good meats; while they always hold an accomplished provider in the highest respect.

Even these few discursive hints are sufficient to show that it is nearly as cheap and as easy for persons in moderate circumstances to provide good material as to take that of inferior quality; but it will not answer to trust entirely to the dealer, although he may seem a very pattern of honesty. Those who appreciate good things sufficiently to attend personally to their selection will always have the first choice, and others must take what is left. Heads of families and housekeepers should bear these facts in mind and remember as well that scientific investigation has shown that well-flavored articles are more easily assimilated and nourish the body better than those of inferior quality. Young and growing children especially should have good and sufficient nutriment. One of the causes of the deficiency in vigor and endurance in many fashionably educated females is the insufficient nourishment to which they are subjected in boarding-schools, at the most critical period of their existence. This subject,

to which I have already alluded in the first article, has often engaged my thoughts; and I have more than once seriously considered the propriety of making a systematic attack upon the dietetics of the boarding-school system, based upon estimates of the quantity of nutritive material required by young girls compared with that which they actually receive. Physiological gastronomy abhors the idea of young and growing girls or boys actually suffering from hunger, as they sometimes do, until the appetite is brought down to what is considered to be the proper standard. A frequent result of this regimen in early life, particularly in females, is a physical condition in adult years which is truly pitiable; and this in persons who are supposed to have an abundance of the best of everything.

Meats should be kept for a certain time before they are eaten. This is necessary to the development of the best qualities of nearly all kinds of food derived from warm-blooded animals. The length of time that such articles should be kept must of course vary with the weather and with other conditions. It is not proper to allow any putrefactive change, although the antiseptic properties of the gastric juice are so decided that substances even in rather an advanced stage of decomposition may occasionally be taken into the stomach with impunity. Meat should be kept in a cool and moderately dry atmosphere until the nitrogenous substance has undergone some of the changes which precede decomposition. The tissue then becomes tender and is readily digested; and in this process new empyreumatic and flavoring principles are developed, which add to its richness. Meat should not be frozen, for this disorganizes its structure and impairs its flavor. A great difference in this regard exists between animal and vegetable articles. Vegetables should always be taken as fresh as possible; and when at all decomposed they are invariably injurious.

A strong, healthy man usually regards animal food as his chief reliance; and from what has just been said it is evident that this is in accordance with established scientific facts. It is hardly necessary to add that meat-dishes form the most important part of all good dinners. As these are well-recognized facts, it is important, after having provided good material, to prepare and serve it in the

best manner. The science of modern cookery is, of course, too extensive a subject to discuss in a limited space; and there is a sufficient number of elaborate treatises on this subject to meet the wants of housekeepers. There are, however, certain physiological rules that are appreciated by all good cooks. Those particularly applicable to meats may be expressed in a few words.

The best way to cook meats is to develop and retain in their substance all their peculiar flavors and prevent the escape of the juices. This is done by roasting or broiling, the most physiological of all methods of cooking. The external portions should be rapidly hardened by a quick sharp fire, but never allowing the meat to burn. The temperature to which the surface is thus exposed ranges from 212° to 270°; and this effectually prevents the escape of the aroma and the juices. The interior, which is not exposed to very intense heat—not more than from 125° to 150°—should be cooked thoroughly; but always, in the case of meats and dark-meated birds, so as to be full of a clear, red juice, and never allowed to become dry. Articles that are broiled in this manner need little more than a little sweet butter added after the cooking is completed. There is nothing that broils so well as old-fashioned hickory coals; and next to these, charcoal. The hard range-coal cooks too slowly and often gives a slight smoky flavor to the meat. Above all, let broiled meats be taken immediately from the coals to the table. The extemporaneous steak or chop will always be found to be the best.

Boiling is a mode of cooking the value of which is somewhat underestimated. Mutton and some kinds of poultry are very good boiled. It is desirable to boil meats in water that has been well salted, otherwise too much of the nutritive matter is extracted. It is manifestly impossible to make a good soup and leave a good piece of boiled meat. Boiling seems simple enough, but it requires a certain degree of care. If meat is immediately plunged into boiling water it becomes tough; but the water with the meat should be put over a sharp fire and be cooked much more rapidly than when soup is to be made.

Baking is one of the worst methods which can be employed in cooking meats, unless they are baked so rapidly

that they are actually roasted. The difficulty with baked meats is that they are likely to be tough, and the juices with some of the aromatic principles almost invariably are destroyed.

In stewing, the culinary artist has an opportunity to supply flavor by means of sauces to material that would otherwise be insipid; and this enables him to sometimes make use of tough and inferior meats. This is a very important method of cooking; and the variety of dishes that can thus be made is very great. The remains of roasted or boiled meats can be made use of in this way, and if skilfully prepared, can be made quite palatable.

Good meat should not be fried. The fat used in this process always has a higher temperature than it is desirable to obtain in the substance of meat, and the muscular tissue readily absorbs the hot liquid, rendering it disagreeable to the taste and difficult of digestion. The flavors of meats are almost always destroyed by frying. Oysters, fish and articles of this kind, which are cooked very rapidly, may be fried when properly protected by meal, bread-crumbs or batter; but there are few meats which can not be better cooked in other ways.

In following out the original plan of these articles, meats will receive more attention than other kinds of food; and after the few hints that I have given concerning their selection and preparation, I shall endeavor to indicate their physiological place in a dinner.

NO. V.—MEAT DISHES

It is difficult for those who have not made physiology a special study to realize the extent of this science. In the middle of the eighteenth century, Haller published eight large volumes on physiology (the "Elementa Physiologiæ") with a supplemental volume, making in all more than five thousand closely printed quarto pages; between the years 1837 and 1841, Burdach, assisted by some of the most eminent German physiologists of the day (Baer, Meyen, Meyer, Müller, Rathke, Siebold, Dieffenbach, Valentin, Wagner) published a work on physiology in nine volumes, containing five thousand solid octavo pages; and in 1857, the great French physiologist and

naturalist, Milne Edwards, began the publication of an exhaustive treatise, intended to represent the exact state of the science of physiology, which has already reached eight volumes, making nearly five thousand pages. This great work is now in course of publication and is not more than two-thirds completed. With all this amount of printed matter, no single man has yet proved himself capable of producing a complete treatise on physiology. Restricting the subject even to human physiology, the science embraces not only digestion, respiration, circulation, secretion, etc., but it involves a study of the chemistry of the body and of the food by which it is nourished. It demands accurate and philosophic observation of the workings of the mind, or psychology; which in its turn is intimately connected with the various systems of philosophy and political economy, for man must be studied in all his relations with his fellow-creatures as well as by himself. The animal instincts and the passions should not be neglected; for a study of the human heart is as important a subject for the physiologist in a figurative as in a literal sense. The author of the "Comédie humaine" was, in a certain sense, a great physiologist; and his dissections of the thoughts, passions and motives that belong to humanity are not less accurate than anatomical descriptions of corporeal parts. While sometimes portraying the best qualities of human nature, he more frequently laid bare the perversions and wickedness of man, as the pathologist reveals with the scalpel the hidden diseases of the body. And what can be said in regard to the highest department of physiology, which involves the question of the immortality of man and his relations to infinity! Although this, the greatest of all, generally is left to men who are too often profoundly ignorant of the simplest natural laws, we may possibly in the future know something about physiological theology. I make these remarks to show that almost all subjects are open to the physiologist, and that he has a right to treat of gastronomy in its relations to the mind as well as the body.

The great Balzac did not disdain to write an appendix to the "Physiologie du goût"; recognizing, with other practical thinkers, the influence which the senses exert, permanently as well as temporarily, upon the character

of the human race. It may seem at first that all these considerations have little to do with physiological gastronomy; but the character of nations, as of individuals, is dependent to a great extent on their diet.

A French writer, evidently looking at the subject from a Gallic as well as a physiological point of view, pertinently says "that the grand facts in the life of nations, for which historians assign diverse and complex causes, have their secret at the family fireside! Look at Ireland, and look at India! Would England reign peacefully over a distressed people, if the potato, almost alone, did not aid in prolonging its lamentable agony? And beyond the seas, would one hundred and forty millions of Indians obey a few thousand Englishmen, if they were fed as they are? The Bramins, like Pythagoras of old, wished to soften the manners; they succeeded, but by enervating the men." It is the same with individuals. Tell me what you eat, said Brillat-Savarin, and I will tell you what you are. The moral and intellectual as well as the physical force of men depends a great deal upon diet. A man who does not dine well and has no inclination to do so is generally of a morose, suspicious and morbid disposition and probably is unwilling to enjoy himself while others are doing so in the same way, for fear that he may occasionally lose his self-command and be betrayed into momentary frankness. Contrast one who enjoys an occasional good dinner! Whatever his faults may be, there are times when he is honest and charitable toward others. Our weaker brethren, who have the heart but not the stomach to dine well, are entitled to consideration and sympathy.

There is no occasion which presents a better opportunity for the study of human nature and the relations between mind and matter than that of a really physiological dinner. The experimenter, when operating on the living body, endeavors to carefully remove all disturbing conditions; and the observer of men finds his best opportunity in the naturalness which results from contact with his fellows for the purpose of rational enjoyment. If he is sufficiently practised in the analysis of the human heart and can remain cool and dispassionate, his opportunity is in a small and well-selected company of which the better half is composed of the softer sex. Here the more delicate

springs of human nature are touched; and even in a purely gastronomic sense, an occasion such as this possesses unusual interest. When the feminine palate has been properly cultivated, in nicety and accuracy it is superior to the gustatory organ in the opposite sex. Women are gastronomes by nature; they idealize their food. The slightest suspicion of unneatness, coarseness in the flavor of a single article used or merely an uninviting appearance in any dish is sufficient to excite distaste; while a dish exquisitely decorated, exhaling, perhaps, an indefinite and dreamily delicious odor which promises a new sensation, excites the imagination and generally carries the gustatory enjoyment to a point which most men can not reach. This is particularly the case with delicate wines. A woman's palate has not known the violent shocks which men's tastes so frequently experience. They are seldom called upon to "take a drink" with a friend, the liquid being, perhaps, an ounce of "red-eye" whisky; the brain-consuming gin; brandy, so called; and other vile distillations and mixtures too many to mention. It is a moral and physiological sin to take these fiery draughts; and one of the penalties is a loss of delicacy of the sense of taste.

But to return to the subject of dining. The different shades of feeling which are so apparent just before dinner is announced, and during what may be termed the uncertain period, when the character of the function has not been developed, have often been portrayed. You have dressed and have prepared the appetite carefully for the occasion, arrived at precisely the appointed time, and an important guest is delayed. Conversation is impossible; your compliments to ladies, if they are present, are flat and unheeded; the only persons who take any satisfaction in the situation are, perhaps, two established "convives," who condole with each other so feelingly and audibly that they have the satisfaction of knowing that they are rendering their host much more uncomfortable than themselves, and an intimate friend of the family, who knows that thirty instead of fifteen minutes have been allowed for unexpected delays. The monotony of such an occasion, however, can be relieved by philosophic contemplations and speculations in regard to the probable thoughts and feelings of the guests. Seated savagely by himself,

with an apparent resolve to bear his misfortunes alone, you may see an acquaintance of prodigious but waning gastronomic powers. You know that he anticipated a sumptuous dinner; and that it is a habit with him on such occasions to stop at his club and prop his failing appetite with a dose of absinthe. This has had the desired effect; but exaggeration of the appetite caused by unexpected delay has given a peculiar ferocity to the facial expression, which is interesting to one who suspects its cause. It would be charitable to inform any one suffering in this way, if he has not already learned the lesson by experience, that he should exercise great self-control and dine carefully or he will make a poor dinner and impair his digestion for several days to come.

Dinner is finally announced. The general expression around the table becomes considerably softened after taking five small, firm, salt oysters with a glass of Chablis, a wine which you think at the time must have been discovered when raw oysters were first eaten. But all is still uncertain; for the oysters may have been an accident and the Chablis sent by a friend. There is still no conversation, although the general feeling is beginning to be decidedly satisfactory.

The soup is excellent; its impression upon the palate is not too decided, yet the flavor is all that could be desired, preparing the gustatory nerves for a glass of sherry—also the right thing in the right place—of fine bouquet, generous and expansive. Perhaps a delicately flavored "bouchée" is now served, and this completes satisfactorily the first step in dining; the probabilities now becoming very strong that everything will progress satisfactorily. Still, the soup may have been sent from a neighboring restaurant and be no indication of what is to follow.

An experienced diner-out looks with anxiety for the fish. Is this to be an ordinary dish, which may be carried off very well, perhaps, by a skilfully prepared sauce, but which intrinsically has nothing to recommend it, or will there be some little agreeable surprise, like a fine shad in February, a Spanish mackerel or a brook-trout in the early spring? Perhaps the shad may not be so perfect as when it is in full season, but when this fish makes its appearance unexpectedly, cooked plainly—an evidence that

the culinary artist has confidence in the excellence of its original flavor—and flanked, perhaps, with a salad of hothouse cucumbers, the heart of the gastronome is filled with gladness; for he knows that nothing short of an unexpected catastrophe can disturb the harmony of the occasion. With a glass of good French white wine, which heightens his appreciation of the fish without dividing his interests, he is prepared to enter upon more serious matters.

At this point everything changes; and this is the only time and place for the introduction of the "pièce de résistance"—the principal meat-dish. With a party of indefinite capacity, chops, sweet-breads, etc., etc., may be introduced before, but this is unphysiological. The palate is now in a condition to appreciate the dish which is to give character to the dinner; and this should be served forthwith. Of all dishes that the ingenuity of man has invented, the truffled turkey or capon is the most delicious. On this point there is no difference of opinion. No other meat-dish can be mentioned in comparison with a turkey, capon or poularde, every fibre permeated with the perfume of the truffle; and the wild turkey of this country, "truffé," makes a dish which has called forth the admiration of the civilized world. It is not sufficient merely to fill a turkey with truffles and cook it. The art is to disseminate the flavor throughout the muscular tissue of the bird. The truffles should be of the best quality; they should be carefully prepared and seasoned; and the bird should be stuffed for days before it is cooked. In this way the truffle has a fair chance. One sees a few black specks in the sauce or in the decorations of many small dishes and recognizes the truffle by the eye but not by the taste. What a contrast in the flavor of a skilfully truffled bird! It seems as though the deficiency in positive flavor of the white meats exists only to be supplied by the truffle.

I once was a guest at the serving of a large wild turkey truffé in the presence of eight persons. The soup was perfect; the fish, an immense yellow pike, was taken from a large tub of its native element to be cooked; but the sensation produced by the sight and odor of twenty-odd pounds of wild turkey and truffles was immense; and every

one felt that the compliment to the turkey, of having the preceding dishes arranged with special reference to this single one, so as to carefully prepare the palate for the supreme impression, was well merited. The host on this occasion did not allow his guests, before the turkey was served, to cloy the palate with ordinary dishes, an evidence of wise judgment and consideration. I have no doubt that the "dinde sauvage truffée" still lingers in the gastronomic recollections of the favored eight; while every other dish has been long since forgotten.

But truffled turkeys or capons are unusual episodes in the experience of most diners-out. Whatever takes its place, however, should be of the first quality. A fine saddle of venison or of mutton, which has been hung and cooked physiologically; a "filet de bœuf"; early lamb, or any good, solid dish, well cooked, is here appropriate. This may be taken with potatoes—which go with any meats—but never with a mass of indifferent vegetables. It makes no difference what nation adopts the style of serving vegetables and meats separately, it is certainly most physiological to do so. There should always be harmony in the combinations of animal and vegetable articles. Peas, spinach, sorrel, turnips, etc., are appropriately served with certain meat-dishes; other vegetables, like asparagus, are highly flavored and delicate enough to be taken alone, and others may be used in salads; but the only advantage in taking a half-dozen different kinds of vegetables with any meat that may happen to be served is that it saves time.

The most substantial meat-dish of a dinner may be followed by others of a lighter character. The first part of the dinner that I have just sketched would warrant the expectation that the principal dish would be something out of the ordinary routine. This will probably be succeeded by two or three delicate small dishes; "côtelettes" in some form, "ris de veau," some of the many dishes of chicken, or any of that array of dishes, the offspring of the fertile invention of French cooks.

The appearance of the meats generally removes the last shade of reserve from even the most formal guest. No one who has dined out observingly can fail to have noted this. Although it is not every one who has the

faculty of making himself agreeable to his neighbor, still all do their best; and if a well-served dinner table is stiff and melancholy, it is the fault of the host in selecting or in placing his guests. It is seldom that conversation becomes sparkling at dinner before the fish. But with the end of what the English call the first course, there generally is a marked intellectual lull. The course of meats and vegetables should close with something which, like white wine with fish, clears the palate and prepares it for fresh impressions. The advantage of this is now recognized by the French, who follow this course with a "sorbet" or delicate water-ice. Aside from its immediate refreshing character, the effect on the appetite is striking; and in the course of an elaborate dinner, it is almost a necessary preparation for game.

If I were disposed to give an account of American game and compare its qualities with the game of other countries, I could find an abundance of material. It is generally acknowledged that there are certain birds, like the canvasback duck, peculiar to this continent, which are superior in flavor to any of the game-birds of the Old World. It is sufficient to say, however, that if there is any part of the world in which game should constitute a part of an elaborate dinner, it is in this country. It makes but little difference what kind of game is used, it is necessary only that it be in full season and well cooked. There are few articles so difficult to cook as game; for what is most delicious in its flavor belongs intrinsically to the meat and should be fully developed in cooking. So far as excellence of flavor is concerned, the dark-meated birds are better raw than much over-cooked. Game should always be good enough to be taken by itself; and except the partridge, when it is very dry, it requires no sauces. Jellies, etc., which sometimes are eaten with dark-meated game, are more than superfluous.

So far as meats are concerned, the game generally concludes a dinner. A reed-bird, half concealed in a leaf of lettuce in the salad, may tempt a vigorous appetite, but most persons are unequal even to this. With the meats, however, some of the vegetables in season usually are served, and these are necessary to the proper variety in the dishes.

Assuming that the sweets and the dessert are properly arranged, a dinner upon the basis which I have just indicated would seem more than sufficient for an ordinary appetite; it should be but an occasional indulgence; and yet it is not uncommon to find, in direct opposition to all the rules of science and gastronomy, tables loaded down with enough material to feed a regiment. The sight of a roast at one end, a boil at the other, with two enormous flanking dishes, to say nothing of vegetables, has a tendency to confuse one's ideas as to what it is proper to eat. The inhabitants of the frigid zones, who sometimes eat twenty or thirty pounds of meat at a sitting, might enjoy such a display, but it is certainly out of place in a temperate climate and in a civilized country.

It should not be necessary to the happiness of any one, as it is not essential to the proper nourishment of the body, to dine elaborately every day. A soup or a fish followed by a good piece of meat with two or three vegetables in season, or meat, bread and vegetables without soup or fish, are all that is necessary; and every one should be able to dine from such a bill of fare as this with satisfaction. Nevertheless, luxury must prevail as civilization advances and wealth increases; and if we ever dine elaborately it should be, as far as possible, in accordance with physiological principles.

The full enjoyment of things of beauty, of emotional music or moving eloquence is in the highest degree sensuous; and these sources of pleasure may not always appeal to the intellect. Such enjoyment is not unworthy or in any sense debasing. The gustatory and olfactory senses are not given to man simply for protection against improper and unwholesome foods and mephitic gaseous or volatile matters; and there is no just reason why these senses should not be cultivated and gratified within proper limits, even if they are sometimes abused by gluttons and drunkards.

XLII

SHORT ARTICLES ON DIETETIC SUBJECTS

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NO. I.—FARM-DINNERS FOR A WEEK

THROUGHOUT the economy of nature there is no such thing as destruction or loss of matter or force. The force which is manifested by the human organism by work represents the metamorphosis of a definite amount of constituent matter of the body. This matter is for the time lost to the animal kingdom; but it is appropriated by the vegetable world and may be again used by animals. The circulation of matter is necessary to the perpetual operation of the machinery of animals; and when an animal, from causes which science has thus far been unable to fathom, has lost the property of regenerating its organism, wears out and dies, another has been developing to take the vacant place. Science has been unable to explain how any particle of matter can be created *de novo;* and we have no positive knowledge that an atom has ever been destroyed.

These physiological principles are exemplified in the highest degree in man. A necessary accompaniment of muscular work is metamorphosis of a certain quantity of animal substance. When the brain, as it is said, produces a thought or an idea, there is a corresponding change of substance. As this process goes on, a certain quantity of substance being constantly lost to the animal and discharged from the organism, new matter must be appropriated in the form of food, as destruction of the body results from inanition, or starvation, and starvation may take place rapidly from entire deprivation of food, or it may go on gradually, from deficiency in quantity, quality

or variety of food. When it is desired to develop to the highest degree the capabilities of the organism for either mental or physical work, food must be taken in proper quantity. It must be of good quality and present the variety demanded by the system. All these facts point to the importance of a physiological diet; and in large bodies of men, where the greatest amount of force is to be obtained, the contrasted effects of physiological and unphysiological feeding are strikingly apparent.

For those who cultivate the soil and thus develop primarily the wealth of the land, proper feeding is a political and social question of great importance; and it is a beneficent provision that in this kind of labor an opportunity is afforded for the use of the best of Nature's gifts to man. This does not exist in cities; and as a necessary consequence, the man who breathes the pure air of the fields and feeds upon the best fruits of the earth thrives under an amount of work that would kill a city laborer, who would find it difficult, sometimes, to do in half a day the " chores " which a farmer does before breakfast.

I believe that it is possible to live better on a farm than in the most highly civilized city, if good cooking is added to good farming. If farmers take advantage of all that is known concerning the breeding and fattening of domestic animals, devote themselves to the raising of vegetables and fruits in perfection, use the delicious fish from the lakes and streams, and the game in which the forests abound, they can attain the limits of gastronomic luxury. There are possibilities which can be accomplished by those only who devote themselves to the table; but farmers can all live excellently well and physiologically out of the soil, without going to market, simply devoting to the table an attention not inconsistent with the profitable working of an ordinary farm.

There are certain staple articles of farm-diet which, with very little trouble, can be had of excellent quality. Hogs are easily raised, and it is not difficult to possess the best breeds. They may be fattened partly with articles which can hardly be used in any other way, and partly with farm-products. It is easy on a good-sized farm to fatten more than the farmer can use; and the extra price for the best pork more than pays for the consumption of

corn. Pork, with laboring men in cities and in the country, is a staple article of meat-diet. Good cooking is impossible without salt pork. At certain seasons there is fresh pork, and from Christmas to the spring-time, the loins, the spare-ribs, sausage, head-cheese, the feet, jowls, etc.; so that the table may be abundantly supplied with fresh meat, while a great part of the animal is preserved for future use. This, with occasional recourse to the last year's barrel of salt beef, and a piece of mutton from time to time, supplies the table well with meat. Poultry does not enter sufficiently into the farmer's diet. This is considered a luxury, as it is profitable to sell and is not absolutely essential to give a proper variety of food. A fat ox or cow may be slaughtered at the proper time, and will furnish roasts, steaks, beef for stewing, etc., in addition to pieces that may be corned. With plenty of potatoes, onions, cabbages, turnips, carrots, beans, peas, etc., and with flour, buckwheat, corn meal, eggs, butter and cheese, there is no difficulty in securing an abundant variety for the table during the winter, without actually buying anything but tea, coffee, sugar, spices, salt and a few other groceries.

Mechanics, and laboring men generally, in cities, earning much more in actual money than the ordinary class of farmers, have no such material, either in quantity or quality, from which to make out the bill of fare for the week; and with the exercise of fair skill in cooking, the farmer should never fail to have a good dinner. By laying out a programme for every day in the week, it will be seen how, with modifications for different seasons, a good and sufficiently varied diet may be secured by using almost exclusively the products of the farm:

Sunday.—Cold corned beef, cold-slaw, pickles, pork and beans, fried potatoes, bread and butter, cold rice-pudding, cheese and tea.

On Sunday it frequently is most convenient to have a dinner which it does not take long to prepare. The cold boiled corned beef may be from the Saturday's dinner. It is a good old New England custom to prepare pork and beans before church. Put in the oven, with a slow fire, in the morning, it will take care of itself until noon, when the top will be nicely browned. Boiled or raw potatoes,

sliced, may be fried in a few moments, and the dinner is ready.

MONDAY.—Boiled bacon and cabbage, or greens, potatoes, turnips or carrots, bread and butter, boiled Indian-pudding and molasses.

TUESDAY.—Irish stew, potatoes and other winter vegetables, bread and butter, apple-pudding or pies.

Irish stew is an excellent and an economical dish. It usually is made of the neck, breast or stewing parts of mutton, but beef or veal may be used as well. The stew should be made over a slow fire, with the meat cut into small pieces, well seasoned with salt, pepper, a little sugar and a few onions. Potatoes cut up are to be added, and if desired, carrots and turnips.

WEDNESDAY.—Roast-beef, pork, mutton, or poultry; potatoes, onions, bread and butter; mince-pie or suet-pudding.

THURSDAY.—Good pea or bean soup with fried bread, plenty of pork served on another dish, winter vegetables, pickles, bread and butter, pumpkin-pie.

FRIDAY.—Vegetable soup, picked-up codfish, potatoes, turnips, carrots, onions, winter-squash, bread and butter, boiled pudding and cheese.

SATURDAY.—Boiled corned-beef and cabbage (enough to last over Sunday), potatoes and other winter vegetables, bread and butter, boiled rice and molasses.

In addition, fruits in season, cooked or uncooked, fresh or dried or preserved should be used at proper times.

With a little care, this bill of fare may be modified weekly to a very great extent. Steaks, chops, veal in various forms, boiled fresh beef garnished with vegetables, fresh fish, green goose stuffed with potatoes and onions, etc., etc., may be introduced from time to time, and a cup of tea or coffee, cider or home-made beer occasionally will be much relished. If farmers take care to live well, they will do more work and enjoy better health than if the diet is monotonous and the food carelessly prepared. While, with proper and sufficient food, hard work develops the mental and physical powers, with an unsuitable and careless diet, the same amount of labor is wearing, and we grow old too fast, a tendency which is peculiarly marked in our own country.

NO. II.—HOW TO MAKE THE MOST OF A VEAL

In common with many physiologists, my views in regard to veal as an article of human food have not been entirely favorable. It is true that a calf furnishes many excellent dishes, such as the sweetbread, liver, calf's-head and some of the so-called made-dishes; but veal itself is not to be compared with pork, mutton or beef as a prime article of diet. It is profitable to kill at the proper age some of the calves on a farm and the whole carcass can be disposed of to advantage, every part serving some useful purpose; and in farm-diet, the variety furnished by veal is grateful and beneficial after being confined for a long time to other meats; but veal should be taken as an article of luxury, and it can not be depended upon as working food.

What I shall have to say concerning veal is more for the town than the country. When a farmer wishes to kill a calf, he has the opportunity of selecting an animal of proper age and is sure that it has been fed and raised in such a way as to secure good meat. He should keep the best quarter for his own use and sell the other parts. If his culinary department has the proper organization, he will not throw away the sweetbreads and head, as is frequently done in the country, but will cook them carefully and thus secure several excellent and even luxurious dishes out of what some consider refuse parts. I have known butchers in the country to discard the sweetbreads and head of the calf as useless; though this fact may seem strange to city marketers, who know, to their cost, that the value of these delicacies is fully appreciated in town.

The criticisms which I shall have to make on veal are chiefly physiological; and I am quite willing to admit that when properly prepared it is a palatable article of food. In the first place, no immature meat is so good or nutritious as the same article after the animal has arrived at its full development. Lamb is not so nutritious nor so good, in the long run, as mutton. Half-grown poultry is not so good as the best of full-grown birds. Our staple articles of food, both animal and vegetable, consist of meats and vegetables in their maturity. New potatoes, spring-chickens, squabs, etc., etc., are luxuries

and not articles that we wish to feed upon day after day. There are some exceptions to this general proposition, particularly in certain vegetables, such as beans and peas; but veal is not one of them. Nothing is better than beef plainly cooked—as a well-broiled steak; but a piece of veal cooked in the same way would be almost tasteless. To make a good dish of veal, the meat should be larded, cooked with plenty of salt pork and served with an abundance of seasoning, gravy, etc.; and even then it soon becomes monotonous and distasteful.

In its chemical composition, veal presents certain important differences from beef. It contains more water, less organic matter and salts, and is notably deficient in empyreumatic principles. It is this last peculiarity which makes veal more insipid and demands, in its preparation for the table, so much seasoning. It has been ascertained experimentally that veal is less digestible than beef. These facts, while they are not opposed to the use of veal as an article of luxury and for the purpose of contributing to the variety in diet which is necessary to proper nutrition, coincide with the generally received view that veal is not very desirable as an article for constant use.

When veal is well cooked and handsomely served, the delicate appearance of the meat renders it attractive; and in killing and dressing, butchers keep in view the fine grain and delicate color which are so highly prized. But there are certain important points to be remembered in buying veal in the shops. There is a meat often sold, commonly known as "bob-veal," which is decidedly unwholesome and is likely, in delicate organizations, to produce disturbances of digestion. This kind of veal is simply too young; in some instances the meat being sold before it is a week old. It may be laid down as a rule that veal less than four weeks old is unfit for human food; and the only way to determine the age in the shop is by the size of the carcass and the texture of the flesh. A veal should weigh about one hundred pounds, certainly not less than eighty; and the flesh should be firm and finely grained. If the carcass is lighter and if the meat is stringy, soft and watery, the veal is either too young or the animal has been subjected to great fatigue in transportation just before killing. It is difficult to find an explanation in chemical analysis of

the injurious effects of such veal when taken as food, but the fact is beyond question.

Another important point in buying veal is to avoid meat which is extraordinarily white. It has been the custom, and is now to a certain extent, for butchers to bleed their calves daily for two or three days before killing, taking several quarts of blood at each operation. This will render poor, dark-colored meat white and fair-looking; but when it is cooked, it will be found dry and tasteless. Good veal, four to six weeks old, fed only from the cow, is the best. This is white, finely-grained, juicy and firm. After six weeks, when the animal requires more nourishment than is furnished by the cow and is beginning to eat grass, the flesh is darker and is dry and tasteless. If at that time the butcher attempts to whiten the meat by bleeding, he does so at the expense of the little flavoring which it contains. After six weeks, as a rule, the flesh of the calf is not good. It is then neither veal nor beef.

It is a general impression that the veal in France is better than in this country; and this is well founded. In France more attention is paid to feeding animals destined for the table than here. The poultry is generally better for that reason. The meats are as a rule more carefully inspected by the public authorities in France than elsewhere, and, most of all, the cooking is more scientific. If there is any kind of meat that requires special care in its preparation for the table, it is veal; and the "grand sauces," which are used in almost all of the so-called made-dishes, are almost unknown out of France, except in a few first-class restaurants.

"Blowing up" of carcasses is one of the tricks of the butchers' trade that was formerly quite common. To make a carcass look plump and fair, butchers were in the habit of blowing into the cellular tissue. The only effect of this is to make the meat look and sell better, and it has no influence on its flavor or quality.

On the whole, veal at proper times and seasons is very good; and there are few animals of which every part can be so thoroughly utilized and that furnish material for so many good dishes if properly prepared. Calf's-head, brains, sweetbreads, kidneys, liver, heart, lights, veal roasted, stewed, stuffed, boiled, veal-broth, calf's-foot jelly, are all

good; but in dishes cooked simply, where the excellence depends on the nutritive qualities of the meat, and the agreeable taste, on the development of its own flavoring principles, there are few articles of meat diet that are not superior to veal.

NO. III.—HOW TO MAKE A GOOD CUP OF COFFEE

No one can learn how to make a good cup of coffee without being able to appreciate all the qualities which belong to this, the most delightful of beverages. Tea is one of the drinks "that cheer but not inebriate"; but coffee not only cheers, it inebriates, and in the most harmless fashion; but best of all, it leaves no trace behind, except a desire for a repetition, at proper intervals, of the same sensations. Nothing can take the place of coffee; whether it be regarded with the critical eye of the physiologist or the sensual appreciation of the epicure. What is a good cup of coffee? A cup of coffee must be made with coffee and nothing else.

Looking at the coffee question as it affects individuals, and excluding those few who are constitutionally opposed to coffee, the usual effect is as follows: By its gentle, stimulant influence, it excites the brain to healthful and cheerful work and provides against subsequent exhaustion. It enables sedentary persons to eat more moderately and to digest their food better. It prepares for unusual mental or physical strain. It more surely than anything else removes, almost magically, the exhaustion which follows extraordinary labor of any kind. Allowing for idiosyncrasies, coffee, taken in moderation, has no bad effects, either immediate or remote.

Studying the action of coffee from a physiological point of view, we should look upon the effects, not only as observed in individuals, but as they are shown in large bodies of working-men. In the Belgian mines at Charleroi, the diet of the workmen was found, by chemical examination and estimates of the labor that should be accomplished in a given time by the force employed, to be deficient, particularly in nitrogenous matter. The addition of coffee to the ration enabled the men to perform an amount of labor which could not otherwise be obtained

with their scanty supply of food; and the diet was even below that found necessary in prisons and elsewhere, where coffee was not provided.

A good cup of coffee is an infusion of good, pure coffee, its aroma fully developed, without loss or destruction of any portion of it, by proper roasting of the berry, and all its virtues extracted with boiling water.

There are two kinds of coffee: the first may be called superlatively good coffee and this must be made with care and without regard to trouble or cost; the second is simply good coffee and is good enough for ordinary use. This must also be made with care, but certain economical considerations are not inconsistent with its proper preparation.

Superlatively good coffee must be made in accordance with certain principles concerning which there is little room for differences of opinion. First, the original coffee must be ripe and old; second, it must be freshly roasted and ground; third, it must be extracted with water in brisk ebullition; fourth, after roasting and grinding, it should not touch metal; fifth, it is necessary to use a large quantity of coffee.

After some experience in various kinds of coffee, including the celebrated Cuban coffee, the Costa Rica coffee and other varieties, each purporting to be the best in the world, it has seemed to me that nothing is equal, in delicacy of flavor or in stimulating effect, to the best of old Mocha. Many of the French consider that the best cup of coffee is made by using equal parts of Mocha and Java; but after repeated trials and investigation of the probable ground for this preference, I am led to believe that Java is used generally from motives of economy, a question which should not enter into the preparation of the best coffee. It is true that in a mixture of equal parts of Mocha and Java there is the peculiar aroma of the first with the rich body of the latter; but this is not equal to coffee made with pure Mocha.

Fine old Mocha should be carefully picked over so as to exclude every imperfect berry. It would be well, then, to spread out the coffee on a platter and expose it for a few hours to the sun. The next process is to roast it. This is best done in an iron barrel over a very slow fire,

constantly turning it, allowing the grains to swell very gradually, and examining the coffee from time to time to see that it does not become of a darker color than a mahogany brown. It should then be allowed to cool slowly, and when cool, the grains should be picked over again, so that the coffee used shall be of uniform color. By careful torrefaction, the peculiar aromatic principles of the berry are developed; but when the coffee is burned, there is a quantity of acrid matter produced which is disagreeable to those who have learned to recognize the true flavor.

So soon as the coffee is entirely cold, it should be ground, neither very coarsely nor very finely, and the infusion should then be made immediately. The Arabs pound their coffee in wooden mortars, which become impregnated with the aroma and are very highly valued, being handed down in families, it is said, from generation to generation. But the Arabs do not separate all of the grounds from the extract; and I do not know that pounding in a wooden mortar gives any peculiar qualities. It is well, however, to see that the mill used for Mocha is not used for the inferior grades.

The principle in making good coffee is to develop the aroma as much as possible and to extract with boiling water the pure coffee. For this purpose the simplest percolators are the best, but they should not be made of tin. Filtering coffeepots of porcelain or earthen ware are readily obtainable. These are perfect. They can be kept absolutely clean, and coffee made with them is never acrid. With the ordinary tin filters, the coffee remains in the joints, and often gives to the fresh coffee an acrid, disagreeable taste. It also comes in contact frequently with the iron, and forms ink. It is easy to imagine that a very small quantity of ink will destroy the flavor of a large cup of coffee. In porcelain coffeepots, the thickness of the filter is so great that it is likely to clog with the grains; and it is so coarse that the liquid does not come through perfectly clear. Both these difficulties may be obviated by using at the bottom of the filter a circular piece of flannel, which may be washed and will last for a long time.

Before putting in the ground coffee, the apparatus and the cups should be warmed with boiling water. The coffee is then put in and moistened with boiling water for one

or two minutes. Then a sufficient quantity of boiling water is poured in and the coffee is made. To make two cups of the best coffee, use a cup and a half of ground coffee, and pour boiling water through once, having cups and coffeepot hot. The proper time for coffee made in this way is after dinner.

To simplify this process, I may give seriatim the steps for making after-dinner coffee: Heat the water in a porcelain vessel over gas, if convenient. While the water is boiling, grind the coffee. When the water has boiled, pour it into the two coffee cups, and from the cups into the coffeepot. Use three cups of water to make two cups of coffee, for about one cup of water will be absorbed. Pour the water from the coffeepot into the saucepan. Put in the coffee, moisten it with a little of the hot water, and allow it to soak until the water boils again briskly. Then make the coffee by pouring the boiling water through once. A small cup of this coffee will be sufficient for any ordinary nervous system. It is too strong to be taken in quantity at breakfast.

The best recipe for making ordinary breakfast coffee was invented by Soyer. Take two ounces of good ground coffee (Java or Java and Rio); put upon the fire in a stewpan (porcelain-lined), and stir with a spoon until hot, never allowing it to burn; pour over it a pint of boiling water and keep it hot on the fire for five minutes, without allowing it to boil; finally, strain through a cloth, and warm again for use, carefully avoiding boiling. The cloth should be washed out immediately and may be used over and over again. To make good "café au lait," add to a pint of coffee made as above a pint of hot boiled milk and warm to near the boiling-point.

The practice of boiling coffee can not be too strongly condemned. Boiled coffee is nearly as bad as boiled tea, and is much more common; indeed, coffee is often made by boiling with water and settling with white of egg, fish-skin or some such substance. It is a fact, theoretically presupposable and actually demonstrable, that every moment of boiling drives off a certain portion of the volatile aromatic principles of the coffee, upon which its excellence and stimulating properties depend.

NO. IV.—WHERE TO CUT AND HOW TO BROIL A GOOD STEAK

There is one gastronomic advantage which the city possesses over the country, and that is in the selection of beef. There is no reason why a country gentleman should not have the best mutton, lamb, veal, poultry and vegetables; but it is not easy to buy good beef, unless one has a large amount of material from which to choose; and even then, there is nothing more difficult to select than beef. The meat may present the characteristic marbled appearance, the fat may be of good color and consistence, the grain of the meat fine to the touch, and yet, from over-driving and fatigue in coming to the slaughter-house, from improper feeding just before killing or for reasons which it is impossible to explain, the meat may be tough and badly flavored. A little care and experience will enable one to avoid serious mistakes with almost all kinds of meat and poultry, but beef is uncertain.

Butchers are often in error in their appreciation of the qualities of beef. In the first place, the large prize beef is frequently not good, for the reason that the animal has been fattened to an unusual extent and with abnormal rapidity. The meat consequently is deficient in flavor. There is probably nothing better than a young spayed heifer that has been reared with plenty of air and is not too fat. A carefully reared free-martin is sometimes of extraordinarily good flavor; but these varieties of beef are very uncommon. The best and most nutritious beef is from a large ox, seven to nine years old, that has been moderately worked and carefully fattened without work for some months before killing. Many butchers will say that animals that have never been worked make the best beef; but there is the highest scientific authority against this opinion. The flavor and nutritive properties of meat are best developed when the animal is in the highest physiological condition; and this can not be without gentle exercise and an abundance of light and air.

It is necessary only to taste a good beef-steak once to appreciate that this is the most savory form in which beef can be presented to the palate. There is nothing artificial about a good steak; all the flavor is in the meat

and is developed by cooking; and as a regular dish, no artificial flavors, not even the truffle, are desirable. But very few know where to cut a steak, how to cook it or how to have it served.

The steak usually considered the best is cut from the loin, the piece formerly almost universally used for roasting, and called the sirloin. This is the celebrated porter-house steak. It has the tenderloin, with its soft fat, for those who like the tender meat, and the sirloin, which is more highly flavored. The porter-house steak is better than the tenderloin; the latter is tender, but it has not much flavor, and should be larded or served with some made sauce, to be a good dish. The small sirloin steak is almost as good as the porter-house. A fine steak, one very seldom cut in this country, is from the rib, say the second-cut ribs, which usually are counted the best roasting pieces. This steak, if properly cooked, can hardly be excelled by the best porter-house. It should be an axiom with all good marketers, that no steak can be properly cooked that is less than an inch and a quarter in thickness, and it is better an inch and a half thick.

To broil a good steak is easy, but it is difficult sometimes to make cooks appreciate the importance of minutiæ and to force them to discard certain old-fashioned mistaken notions. To one familiar only with the results of culinary operations, it will seem almost preposterous to say that a good steak should not be pounded; but it is a fact that implements have been devised and constructed for that purpose alone. Do not pound a good steak but flatten it a little with the side of the chopper, trim it properly, prepare it carefully and cook it rapidly.

Some epicures regard it as very important to season the steak before cooking, while others do not put anything upon it until it is done. This question, about which there is considerable difference of opinion, is of little practical importance. If the meat is good and if the cooking is properly done, it makes little difference when the steak is salted and peppered.

To prepare the steak, rub in salt and pepper well with the hand and grease both sides slightly with sweet lard or fresh butter. Use no butter of inferior quality, commonly known as cooking butter. The steak thus prepared

should then be placed between the bars of a well-warmed light broiler, so that it can be easily turned over the fire. The preparation of the fire is the most important point of all. The very best is a clear fire of bright hickory coals. The next is a charcoal fire; but a bright fire of ordinary coal will broil pretty well. It is indispensable that the fire be hot and clear; and there should be no smoke from dripping gravy, which can easily be avoided with proper care. Put the steak over the fire, and turn often until done. When done, place it upon a hot dish, sprinkle over it a little more salt and pepper, spread over it a little sweet butter, and let it be served and eaten immediately. The difference in flavor between a well-cooked steak eaten immediately and one served five minutes after it is done is very great.

Much could be said about the chemistry of such a steak as just described. So far as the development of the aromatic principles of the meat is concerned, this dish is perfect. The brisk heat rapidly coagulates the tissue of the exterior and prevents the escape of the juices, while frequent turning prevents the fibre from being charred. The meat should be cooked entirely through, and the interior should be of a uniform red color, never dark and raw. When such a steak is cut, if the raw material is of the first quality, the dish will be inundated with red gravy which is the real juice of the meat. Such a dish is not only most savory and appetizing but it is very digestible. If physicians would learn to give meats prepared in this way to their patients during convalescence more frequently, recoveries from exhausting diseases would be more rapid and complete; and if more attention were paid to the minutiæ of cooking, health and happiness would be greatly promoted.

XLIII

GYMNASTICS

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Gymnastics (Gr. γυμναστική, gymnastic art) are a system of exercises which develop and invigorate the body, particularly the muscles. If properly directed, gymnastics will enlarge and strengthen the muscles of the trunk, neck, arms and legs, will expand the chest so as to facilitate the play of the lungs, will render the joints supple and will impart to the person grace, ease and steadiness of carriage, combined with strength, elasticity and quickness of movement; but an injudicious mode of exercise will frequently confirm and aggravate those physical imperfections for which a remedy is sought, by developing the muscular system unequally. Although athletic feats were at first performed by each individual according to his own notions and were encouraged among the youth as combining amusement with exercise, they were at length reduced to a system, which in Greece formed a prominent feature in the state regulations for education; and as the nature of the warlike weapons rendered the development of physical force of the highest military importance, athletic sports were continued during manhood. Public games were also consecrated to the gods and were conducted with great ceremony. The earliest mention to be found of gymnastic sports is in Homer's Iliad, book ii., where the Greeks are described as contending at javelin throwing and quoits; and again, in book xxiii., when Achilles instituted games in honor of Patroclus, and distributed prizes to the victors for boxing, wrestling, throwing the quoit, chariot racing, etc. Plato tells that just before the time of Hippocrates gymnastics were made a part of medical study, as being suitable to counteract the effects of indolence and luxurious feeding; and that at

length they became a state matter, reduced to a system and superintended by state officers.

The first public gymnasia were built by the Lacedæmonians. These were imitated at Athens; where, in the walks belonging to one of them called the Academia, Plato instructed his pupils, and in another, named the Lyceum, Aristotle taught. At Athens a chief officer (*γυμνασιάρχης*) superintended the whole establishment; the *ξυστάρχης* superintended only the most athletic exercises; medical officers were in attendance, whose duty it was to prescribe the kind and extent of exercise; the *παιδοτρίβης* assisted and instructed the pupils, who began with easy exercises, from which they were gradually advanced to the more violent, until they reached the highest degree of agility and strength. Baths were attached to the gymnasia; and the system recommended was to take first a hot bath and then to plunge into cold water. Plato and Aristotle considered that no republic could be deemed perfect in which gymnasia, as part of the national establishments, were neglected. The Spartans were the most rigid in exacting for youth a gymnastic training; even the girls were expected to be good gymnasts, and no young woman could be married until she had publicly exhibited her proficiency in various exercises. Honorable rewards and civic distinctions were publicly bestowed on the victors in the games; the rewards were styled *ἆθλα*; and those who contended for them were termed *ἀθληταί*, or athletes. The exercises for the pupils in the gymnasia consisted of a sort of tumbling and war dances; running, much recommended for both sexes; leaping, and sometimes springing from the knees having weights attached to the body; retaining the equilibrium while jumping on slippery skins full of wine, the feet being naked; wrestling for the throw or to keep the other undermost after the throw; boxing, confined almost exclusively to the military and athletes. The boxer either held the hands open, or he clenched brazen or stone spheres, or wore the cestus, or leathern band studded with metal knobs bound round his hands and wrists. There was also a mixed practice of boxing and wrestling, called *παγκράτιον*. The pitching of the quoit was much practised; a variation of the quoit was found in the *ἁλτῆρες*, not unlike a dumb-

bell, which was thrown by one to another, who caught it and then pitched it to a third, and so on; it was also adopted in extension motions and was held in the hand with the arm extended. Javelin throwing was practised by both sexes; also, throwing the bar. Riding, driving, swimming, rowing, swinging, climbing ropes, standing erect for a long time in one position, holding the breath, shouting, shooting the arrow, etc., were also taught.

Modern gymnastics differ considerably from the exercises of the ancients. During the middle ages the knightly amusement of the tournament replaced nearly every other sport, except the use of the quarterstaff, archery, foot-racing and wrestling, which were sometimes practised; so that gymnastics fell nearly into disuse till Basedow, in 1776, at his institution in Dessau, united bodily exercises with other instruction; an example which was followed by Salzmann at his institute, and from this small beginning the practice gradually extended. In the latter part of the eighteenth century gymnastics were introduced into Prussian schools by Guts Muths, who wrote several works on the subject; and about 1810 the system was still more widely spread by Jahn, who may be regarded as the founder of the present "Turnvereine." Prussia being at that time impatient under Napoleonic rule, Jahn conceived the project of bringing together the young men for the practice of gymnastic exercises, at the same time indoctrinating them with patriotic sentiments which might be made available to expel the French from Germany. The Prussian government favored the plan, and in the spring of 1811 a public gymnastic school or "Turnplatz" was opened at Berlin, which was quickly imitated all over the country. On February 3, 1813 the king of Prussia called the citizens to arms against the French, when all those old enough to enter the military service joined the national cause. Jahn himself commanded a battalion of Lützow's volunteers, and after the peace, returned to his gymnastic schools. When, however, there was no longer any reason to dread French invasion, the government of Prussia, regarding the meeting of patriotic young men as a means of spreading liberal ideas, closed the gymnastic schools, and Jahn was imprisoned. In some other countries, however, the system intro-

duced by Jahn was eminently successful, especially in England, Switzerland, Portugal and Denmark. It was first introduced into female education under the name of callisthenics, when systematic exercises were added to hoop trundling, skipping ropes, dumb-bells, etc., already practised by girls, and to riding, archery, and other healthy outdoor exercises among the women. The masculine sports of cricket, football, quoits, boxing, wrestling, baseball, leapfrog, foot-racing, etc., have been for centuries enjoyed by the boys of England in the play grounds attached to the schools. In 1848 the political condition of Europe enabled the turnvereins to be reorganized; and German emigration brought these institutions to the United States.

The first gymnastic society was formed in New York; but similar associations soon spread over the United States. The organization, as first established, was confined to the practice of bodily exercises conducive to physical development; but it soon assumed a higher scope, without neglecting its original object. Libraries were collected, schools were established, a newspaper (" Turnzeitung ") was founded and various arrangements were made for the diffusion of useful knowledge and for mental culture. Thus the turnvereins of the United States tread closely in the tracks of the academy of Athens; and when we consider the intimate connection between mind and body—how the suffering and the well-being of the one are affected by the condition of the other—too much attention can scarcely be paid to the combination of physical with mental improvement. The several local organizations of the turnverein hold annually a general meeting, by means of delegates, for the consideration of matters of common interest; they also have an annual festival, attended by representatives of the several organizations, wherein are exhibited feats of strength and agility, swimming, military manœuvres, rifle shooting, sword exercise, etc. There are, moreover, several local festivals every year in the respective districts.

There are many forms of exercise which require no special skill or practice and which may be employed with advantage by all. Excluding various games, such as baseball, cricket and rackets, and certain special exercises, as

rowing, boxing and fencing, the most available ordinary exercises are walking and horseback riding. Unless one walks rapidly, little benefit is to be derived from this as an exercise. Two or three miles of walking, at the rate of four miles or more an hour, are more beneficial than a much longer walk when the movements are slow and indolent. In the former instance the method of walking is necessarily more natural and more in accordance with the rules laid down by athletes, and the respiratory function is brought into more vigorous action. Horseback exercise, particularly the trot, is also beneficial, gives a free use of the arms and legs, strengthens the back and loins and is generally exhilarating. Outdoor sports, such as leaping, the long and high jump, leaping with the pole, "putting the stone," throwing the hammer, running, fast and long walking, etc., are much cultivated in England and Scotland. The Caledonian games are exhilarating, produce fine and uniform muscular development, and experts in these exercises are almost always models of health and vigor. There are also many valuable methods of exercise that may be profitably employed at home without necessarily having recourse to a regularly organized gymnasium. The best of these are the following: Swinging Indian clubs is an exercise in which there are many different movements, most of which are described in books on gymnastics. This exercise is a good one for the joints, especially the wrists, but does not produce great muscular development or much improvement of the "wind." Exercise with light dumb-bells, five pounds or even less, making a great variety of movements, will develop and harden the muscles of the arms and shoulders, sometimes to a remarkable degree, particularly when combined with more severe gymnastics. This exercise may be continued with advantage almost uninterruptedly for an hour or even longer. A great variety of movements may be performed with an arrangement of elastic bands with handles, made to imitate the pulley weights of a gymnasium. Most of the other exercises of the arms, legs and body, called the free exercises, come under the head of callisthenics. Some of the more simple forms of gymnastic apparatus may with advantage be erected in the open air, and they furnish a useful recreation for schoolboys. Exercises on the

single, or horizontal bar, and the high jump, standing or running, come under this head.

A well-organized gymnasium is provided with a great variety of apparatus by which nearly every muscle in the body may be brought into play. In a complete gymnasium an instructor is necessary at first, particularly for the young, who might otherwise, by carelessness or ignorance, produce injuries which would defeat the objects of the exercise. For the adult, exercise within proper limits in a gymnasium, particularly when taken in classes, not only develops the whole system and regulates the most important functions, but the feeling of emulation excites interest, and the exercise is valuable as a relief from mental strain. This is particularly useful for those of sedentary pursuits. The most simple gymnastic exercises are the following: the upright bars, or chest bars, which render the shoulder joints supple and expand the chest; the leg weights, pushing weights with the feet while in a sitting posture; the pulley weights, which strengthen the arms and shoulders; the rowing weights, an apparatus intended to imitate the movements in rowing; light dumbbells, and club swinging. The more severe exercises are: the horizontal bar, upon which a great variety of feats of strength and dexterity may be performed, many of which require address that can be acquired only by long practice; horizontal and inclined ladders, which are climbed with the hands; climbing the rope; climbing the peg-pole, an exercise requiring great strength in the arms, in which those with light bodies usually are most proficient; drawing the body up with one or both hands; holding the body, suspended by the hands, horizontally, with the face up or down, called the front and back horizontals, requiring great strength in nearly all the muscles; one-arm horizontals, requiring even greater strength; holding the body extended horizontally from a perpendicular bar, the "flag," requiring considerable strength and practice.

The various free exercises known as tumbling, human pyramids, etc., demand much strength, practice, agility and confidence. The most common of these are front handsprings, "flip-flaps" or back handsprings, turning, twisting, etc., on the ground, springing from a lying posture on the ground to the erect position, back and front

somersaults from feet to feet, battoute leaping from an inclined plane, and many other feats, even more difficult, that are performed chiefly by professional gymnasts. Vaulting is a very useful and a simple exercise, which gives agility and develops strength in the arms as well as in the legs. Balancing the body on the hands, walking on the hands, etc., give command of equilibrium. Japanese gymnasts particularly excel in these feats. A good "hand-balance" is difficult to acquire, and its practice is usually begun at an early age by professional gymnasts. Some of the most useful exercises for an expert gymnast are performed in great variety on the parallel bars. The parallel bars constitute perhaps the most useful apparatus in the gymnasium, for developing the muscles of the shoulders, the chest and the back. The single and the double trapeze are now much in vogue with gymnastic experts. The flying trapeze is not much used by amateurs, as this exercise is not devoid of danger, and almost all professionals acquire their skill in this at the expense of many severe falls. A great variety of difficult feats may be performed with the swinging rings. These are not so dangerous as the feats on the flying trapeze; they develop strength in the muscles of the arms, shoulders and body, and the grip, and are entertaining and agreeable exercises.

Among what are called the heavy exercises, are prominent the "putting up" of heavy dumb-bells with one or both hands and the lifting of heavy weights with the hands or in a harness. Putting up two 100-pound dumb-bells, one in either hand, is justly considered a great feat of strength; it requires great power in the arms and shoulders and particularly in the back. Putting up a single dumb-bell of 100 lbs. or more requires great strength and practice. In putting up heavy dumb-bells with one hand, the weight is carried to the shoulder with both hands and is then raised from the shoulder with one hand until the arm and the body are straight. A single dumb-bell weighing 200 lbs. or even more has been put up in this way with one hand, which is an Herculean feat. In exercises of this kind the muscles should be trained gradually and carefully, otherwise severe strains are likely to occur; but heavy dumb-bells develop the muscles of the back, loins,

thighs and legs, as well as those of the arms and shoulders. Holding out weights horizontally at arm's length is a favorite heavy exercise, particularly with those who have very short and muscular arms. Lifting heavy weights with the hands, or with a harness of straps and a yoke over the shoulders, is an exercise now very much in use. In lifting with the hands alone, the lifter stands on a platform beneath which the weight is suspended; connected with the weight are two handles of convenient shape, at a proper height; the handles are grasped, the legs are slightly bent, the back is hollowed, the arms are straight, the shoulders are in a line with the feet, and when the lift is made the whole body is straightened. With a heavy weight, an instantaneous lift even of an inch is sufficient. The first effort usually is aided by a strong spring, which is compressed by the weight; but the lift must be made to clear the spring completely. Between 1,300 and 1,500 lbs. have been thus lifted. A heavy lift of this kind brings nearly every muscle of the body into action; but it strains particularly the grip, the muscles of the neck and the top of the shoulders, the thighs and the small of the back. Heavy lifts may produce severe strains, unless the lifting position is perfect. Lifters should proceed gradually from light to heavy weights, and should not attempt heavy lifts except under competent instruction. The so-called lift cures are undoubtedly useful, as they condense a great amount of muscular exercise into a very short time. Lifting is sometimes done with a bar between the legs, grasped with both hands; but this position is not so favorable as that with handles by the sides. In lifting with harness, the great strain is taken from the hands and transferred to the shoulders; 3,000 lbs. have been lifted in this way. Expert lifters usually lift every day a weight that they can raise with comparative ease and make a maximum lift only once in two or three weeks. In addition to the above, which comprise most of the exercises of the modern gymnasium, a number of others are sometimes practised, as evolutions on the wooden horse, exercises with wands, etc.

Calisthenics (Gr. κάλλος, beauty, and σθένος, strength) constitute a system of exercises requiring less violence of muscular action than the ordinary gymnastics. This sys-

tem is considered to be better adapted to the more delicate organization of females and generally is confined in its application to that sex. Its purpose is to give equal development to all the muscles and thus produce that harmony of action on which depends not only health, but regularity of proportion and grace of movement. Callisthenics may be practised mediately or immediately, with or without apparatus. All the apparatus required, when used, is a strong chair, a short roller fixed in sockets near the top of an open doorway, a light wooden staff, about 4½ feet in length and half an inch in diameter, a pair of light dumb-bells, a hair mattress, a pair of square weights and two upright parallel bars. The exercises with these are simple and can be readily learned in a lesson or two from a teacher or from any of the many manuals published on the subject. In the chair exercise the pupil plants the feet at a certain distance from the chair and then leans forward on tiptoe and rests the hands upon the back of the chair. The exercise consists in moving the body slowly backward and forward between the two fixed points of the toes on the floor and the hands on the back of the chair. This simple manœuvre is well adapted for expansion of the chest and development of the general muscular system. In the roller exercise the pupil is suspended by the hands a few inches above the floor and swings in this position or moves the grasp alternately from side to side. A number of graceful and strengthening movements may be made with the staff. One of the best is to hold it in both hands and pass it successively over the head to the right and left, bringing it down each time below the middle of the body, in front or behind. The dumb-bells are grasped by the hands and moved forward and backward horizontally from the chest; or with the arms below the hips, they are moved circularly about the body until they meet before and behind. The exercise on the mattress consists in raising the body from a horizontal to a sitting posture, with the arms and legs extended and not used to aid in the movement. The square weights may be used in most cases like the dumb-bells. They have, however, the peculiar advantage of a form which allows of their being placed upon the head. This is one of the best possible means of giving uprightness to the

figure, as in thus balancing a weight, the spine is necessarily brought by the muscles of the back into a straight position. The women of certain countries, who are in the habit of carrying heavy burdens on the head, are remarkable for erectness of the body. The upright bars are fastened by their ends to the floor and the ceiling, at a proper distance apart, and of a thickness to be readily surrounded by the hands; and the body is moved backward and forward between them.

Every necessary exercise may be practised without apparatus of any kind; and a system of callisthenics on this basis is probably better for general adoption, as it is less liable to abuse from intemperate zeal of the pupil, and is more calculated to preserve beauty of form, which few women can be persuaded to exchange for mere strength. When apparatus is used the effort is more violent; and the muscles may become so prominently developed as to cause the absorption of the soft cellular tissue which cushions the human frame, and which, by its abundance in the female, gives roundness and fulness of contour. The constant handling of the hard material of apparatus, also, is likely to produce a disproportionate enlargement of the hands and harden their texture.

Callisthenic exercises without apparatus consist in regular and systematic movements of the entire body. The head and the trunk are moved up and down, forward and backward, to the right and left; the arms and legs and hands and feet are also exercised so that every muscle is brought into action. The object being to give an equal muscular development to the whole body, the exercises are so arranged that all of the muscles are successively brought into action. None of the movements are complicated, and they are in fact no more than those usual in ordinary exercise of the limbs. Callisthenics, however, by reducing these movements to a system, insure an equal and regular action of the muscles, while the occupations of amusements of females often effect the reverse.

The practical utility of all gymnastics frequently is diminished by monotony, the pupil becoming wearied with the uniformity of the movements. Without the discipline of a teacher, it it difficult to secure long persistence in their use. It is well, therefore, to vary them or to associate

with them, as much as possible, the idea of amusement. In fact, there is no better callisthenic apparatus than many of the ordinary playthings, such as the battledore and shuttlecock, the cup and ball and the "graces." In modern callisthenics, regulating the movements to the time of music is much employed and is useful, as it relieves their monotony. Ling, a Swedish authority on gymnastics and callisthenics, has written enthusiastically on the advantage of systematic muscular exercise for the cure of disease. Many ailments to which females are peculiarly liable are due to neglect of proper physical training and doubtless may be relieved in many instances by judicious practice of callisthenics. Most of these disorders may often be attributed to weakness of the abdominal muscles; and a proper strengthening of these by exercise probably would remove the cause. It is evident that callisthenics are almost identical with the lighter forms of regular gymnastic exercise and are adapted to the male as well as to the female. Exhibitions in large classes, the movements being simultaneous and performed to the time of appropriate music, are often quite graceful and entertaining.

Systematic gymnastic or callisthenic exercises are rarely if ever useful before the age of twelve or fourteen years. Professional gymnasts, many of whom begin their training at a very early age, are seldom well formed men, frequently presenting an extraordinary development of certain muscles at the expense of others, which amounts almost to deformity. Before the age of twelve the games and pastimes of childhood generally afford sufficient exercise. At that age, indeed, the lighter gymnastics or callisthenics, under competent instruction, may be the first step in the full development of a muscular system which moderate exercise will preserve in a robust condition throughout adult life. After the age of thirty-five, even practised gymnasts should be careful in making extraordinary muscular efforts. At that time the ligaments are comparatively stiff and strains of the joints often become troublesome and persistent. By persons of sedentary habits, gymnastic exercise is to be employed to secure health; and it is not desirable to carry training to the extent of reducing adipose tissue to the minimum. A fair

development of fat is normal in the adult; and the system is likely to become exhausted if kept too long at a high standard of muscular development. Persons who have an unusual tendency to fat should combine with other exercise, running, jumping on the spring-board and movements which shake the body. These favor the absorption of unnecessary adipose tissue, especially in the covering of the abdominal organs, allow the diaphragm to play more freely and give respiratory power, or "wind." It is a good plan for the adult to use moderate exercise which develops the muscular system generally, and to make one vigorous effort each day, such as lifting a heavy weight or raising a large dumb-bell. This gives nervous power and enables one to put forth easily nearly all his strength in a single powerful effort, when this is required.

It is not necessary for an adult, exercising simply for health, to cultivate excessive hardness of muscle; and indeed the greatest strength is often found in muscles that are comparatively soft. One hour's honest exercise, followed by ablution, usually will suffice for the brainworker; and this should produce prompt reaction without a feeling of exhaustion. Persons who take this amount of suitable exercise are often more powerful and have more endurance than the hard-worked laborer. There is no doubt that judicious and habitual exercise favors the elimination of effete matters from the organism, particularly by the lungs, skin and kidneys, increases the activity of nutrition of the muscular system, rendering the food more relishing, more easily digested, and better assimilated and develops what is known as nerve-power. When it is remembered that the muscles constitute the great bulk of the organism, it is evident that perfect health can exist only when they are properly developed. Active nutrition of the muscles, also, is unfavorable to the deposition of morbid matters, such as are found in tuberculous, cancerous or scrofulous constitutions; and when exercise is combined with amusement and mental relaxation, the system is in the best condition to secure its full benefit.

Ancient gymnastics are treated of in a few works: Plato, "Politics," book iii., and "Laws," book viii.; Galen, "On Preserving Health"; and Hieronymus Mercurialis, "De Arte Gymnastica," book vi. (Venice, 1587). On

modern gymnastics there are many treatises. Some German physicians have endeavored to elevate gymnastics to the importance of a science, especially Dr. Schreber of Leipsic; see his "Kinesiatrik" (Leipsic, 1852) and "Aerztliche Zimmergymnastik" (5th ed., 1858). The more recent works published in the United States and England are the following: Arthur and Charles Nahl, "Instructions in Gymnastics," San Francisco, 1863; Watson, "Callisthenics and Gymnastics," New York and Philadelphia, 1864; William Wood, "Manual of Physical Exercises," New York, 1867; Ravenstein and Hulley, "Gymnastics and Athletics," London, 1867.

NOTE.—In this article I have not made a distinction, which is usually recognized, between athletics, chiefly outdoor exercises, and gymnastics. Practically, this distinction is somewhat artificial and is unnecessary. (November, 1902.)

XLIV

PUGILISM

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Pugilism (Lat. *pugil*, a boxer) is the art of fighting with the fists, practised in modern times according to certain rules known as the rules of the English prize ring. It is said that Theseus was the inventor of the art of boxing, or the skilled use of the fists and arms in assault and defence. Homer describes pugilistic encounters, and Pollux, Hercules and others are mentioned as excelling in pugilism. Boxing was one of the most important exercises in the Olympic games. The ancient pugilists fought with the "cestus," formed of strips of leather wound around the fist and arm, frequently as far up as the elbow. This was sometimes studded over the fist with knobs loaded with lead or iron and was practically the same as the "brass knuckles" of the present day. The cestus used by the Greeks was of various kinds, called *μειλίχαι, σπεῖραι, βοεῖαι, σφαῖραι,* and *μύρμηκες*. The *μειλίχαι* were the softest, and the *μύρμηκες*, the hardest. The rules of boxing in ancient times resemble those of the modern prize ring, except that wrestling was not permitted. The right arm was used chiefly in offence, the left arm serving to protect the person. The ears were much exposed to injury in the old games, and they were sometimes protected by covers. With the cestus, especially when loaded with knobs of metal, the ancient pugilistic encounters must have been terribly severe, resulting often in mutilation and sometimes in death. At the Olympic games the boxers usually were naked or wore simply a girdle around the loins. In the earliest times boxing at the games was permitted only between freemen and those who had not committed crime. Contests between boys were early introduced at Olympia.

The art of boxing, as now practised, may be said to date from the building in London of a theatre for exhibitions of the "manly art of self-defence" by one Broughton, about 1740. Broughton, who for eighteen years was champion of England, is said to have invented boxing gloves. He held exhibitions in his theatre and laid down certain rules for fighting, quite similar to those of the present day; but for many years before the time of Broughton, pugilistic encounters had been common at fairs and festivals in England. The funds for the erection of Broughton's theatre were provided by about eighty of the noblemen and gentry of England, and the encounters were witnessed by the best blood in the land, including the Prince of Wales. Jackson, who was champion in 1795, is now regarded as having been one of the most skilful professors of the art. He gave instruction to many of the aristocracy, among whom were Lord Byron and Shaw, the life-guardsman. The prominent points in Jackson's system were the use of the legs in avoiding blows, and the correct estimate of distance, striking no blows out of range. In 1817 the future emperor Nicholas, of Russia, witnessed a prize fight in England, and shook hands with the victor. Since that time, however, the prize ring has gradually fallen into disrepute; but for a long time the principle of "fair play" was strictly adhered to in England. At the present day prize fighting is practised only in Great Britain and America. The brutality of such exhibitions has at last excited general condemnation; and for more than half a century the practice has been under the ban of the law. The rough character of the assemblages on such occasions and the frequent "selling out" and fraud in the encounters have disgusted those of the professors and patrons of the "manly art" who believed in fair play. It is thought that few of the fights that have occurred within the past few years have been honestly conducted.

Although prize fighting has deservedly fallen into disrepute, many persons practise boxing for exercise and amusement. The rules of the prize ring (commonly abbreviated to P. R.) are briefly as follows: The ring shall be on turf, formed of a square of twenty-four feet, bounded by a double line of ropes attached to eight stakes. The

lower rope is two feet and the upper, four feet from the ground. The choice of "corners" is determined by the toss of a coin. The winner selects his corner according to the state of the wind and the position of the sun, it being an advantage to have the sun in his opponent's face. The loser takes the corner diagonally opposite. A space is marked off in each corner large enough to accommodate the man, his second and his "bottle-holder," who are allowed to attend their man in the ring. The colors of the men are tied to the stakes at their respective corners. Each man names his second and bottle-holder. The seconds agree upon two umpires, one for each man. The umpires usually select a referee, unless one is agreed upon in some other way. The referee directs the contest and decides the fight and all questions of fairness. His decision is binding and final. The umpires watch the fight in the interests of their respective men and call on the referee for a decision regarding all questions of fairness. The referee withholds all expressions of opinion until he is appealed to by the umpires or until the end of the fight. The referee and umpires are so placed as to be able to watch the fight; but no one is allowed within the ring except the men with their seconds and bottle-holders. The men are stripped, before the fight, by their seconds and dressed for the contest. The dress usually is knee breeches or drawers, stockings and shoes, the soles of the shoes being provided with spikes three eighths of an inch long and one eighth of an inch broad at the points. The men are naked above the belt. The seconds and umpires see to it that no improper articles are used in the dress. The men are allowed nothing in their hands and no resin or other sticky substance is allowed on the fists. One of the umpires is selected to act as time-keeper. It is his duty to call "time" at the expiration of thirty seconds after each round. If one of the contestants fails to come to "the scratch" within eight seconds after time has been called, he loses the fight. The scratch is a straight line drawn through the centre of the ring between the two corners. The bottle-holder is provided with a bottle of water and a sponge, and it is the duty of the second and bottle-holder to take their man to his corner at the close of each round, render him all needed assistance there and bring him to the scratch

when time is called. The second and the bottle-holder are not permitted to approach their man during a round or to give him advice at that time, and are cautioned not to injure the antagonist when they pick up their man at the close of a round. When the man can not come to the scratch at the call of time, the second usually throws up the sponge as a token of defeat, and the victor takes his antagonist's colors as a trophy.

The men being ready, time is called, and each man is conducted to his side of the scratch by his second. The men shake hands with each other, the seconds do the same; the latter retire to their corners and the fight begins. When time is called after a round, the principal rises from his second's knee and walks unaided to the scratch. A round is considered closed when one or both men are down, either from a knock-down blow or from being thrown after they have closed. Unless there is a knock-down, the rounds usually terminate in a clinch.

The following acts are considered foul: wilfully falling without receiving a blow at the time of falling, except that one may slip from the grasp of his antagonist after the men have closed; butting with the head, gouging, scratching, biting, kicking or falling on the antagonist when he is down; striking the antagonist below the belt or grasping him by the legs, and striking the antagonist when he is down (a man with both knees or with one hand and one knee upon the ground is considered down). If one of the umpires claims a foul, the referee may caution the man and his second or may declare that the man against whom the foul is claimed has lost the fight. The referee's judgment is based usually on his opinion as to whether the foul was intentional. In case of disputes the men retire to their respective corners pending the decision of the referee. In case any circumstance interferes with the progress of the fight, the referee may appoint another time or place of meeting, at which the fight is to be continued; but unless it is concluded within a week, the battle is considered drawn. The referee has power to cause the men to be separated when one is in such a position across the ropes as to be helpless or in danger of his life.

The first prize fight in the United States took place in 1816, between Jacob Hyer (father of Tom Hyer) and

Tom Beasley, the result of which was a " draw." The rules of the ring were observed during the first part of this fight, but it soon degenerated into rough-and-tumble, and friends of the men interfered after one of Hyer's arms had been broken. This was followed by many fights of a more scientific character. Among the most celebrated was the fight between Tom Hyer and " Yankee " Sullivan, in 1849. Many other fights occurred between 1849 and 1860, when the so-called great international fight took place in England between John C. Heenan, of New York, and Tom Sayers, champion of England. This was a severe contest, and the general opinion has been that Heenan was the winner, the fight having been interrupted by breaking in the ring. The day after, the referee decided that the contest was a draw.

In the accounts of fights, particularly those published in the earlier history of the English ring, the slang words and expressions used are peculiar, and some of them are quite descriptive and suggestive. The following are some of those commonly met with in pugilistic literature: " Bellows," lungs; " bellowser," a blow in the pit of the stomach, taking one's breath away; " blinker," a blackened eye; " bore," to press a man down by force of weight and blows; " brain canister," " knowledge box," " lob," " lolly," " nob," the head; " buff," the bare skin, as " stripped to the buff "; " cant," a blow; a " cant over the kisser," a blow on the mouth; " castor," a cap (before entering the ring, the pugilist generally tosses in his " castor "); " chancery," a position in which a pugilist gets his opponent's head under his arm; " claret," blood; " claret jug," " conk," " nozzle," " proboscis," " snuff box," " snorer," " snout," the nose; " cork," to give a bloody nose; " daylights," " goggles," " peepers," " squinters," the eyes; " fancy," a general name for pugilists; " fibbing," striking blows in quick succession at close quarters; " fives," " a bunch of fives," the fist; " fives-court," a boxing hall; " send to grass," to knock down; " groggy," used to describe the condition of a pugilist when he comes to the " scratch " weak on his " pins "; " grubber," " kisser," " oration trap," " potato trap," " whistler," " ivory box," the mouth; " mauley," the fist; " mill," a fight; " mourning," " to put the eyes in mourning," to blacken the

eyes; " painted peepers," blackened eyes; " pins," the legs; " portmanteau," the chest; " rib roaster," a blow on the ribs; " smeller," a blow on the nose.

A closely contested prize fight taxes a man's strength, endurance and " pluck " to the utmost; and however courageous he may be, poor physical condition is so great a disadvantage that it can hardly be overcome in the face of good condition in an antagonist, the skill, courage and strength of the men being nearly equal. It has therefore been considered of the last importance to bring a man into the ring perfectly trained. The duration of rigid training depends largely on the previous muscular condition; but two or three months usually are sufficient.

Without going into the minutiæ of the different training systems, it will be sufficient to indicate the general method and the main objects to be attained. Fat is inert, useless matter during a fight, and is to be eliminated from the body so far as is possible without depressing the nervous energy. The muscular system should be developed to the highest degree. The nervous system should act promptly and perfectly, a condition essential to endurance, which is probably the most important quality in a pugilist. The respiration should be free and performed with the smallest expenditure of nervous and muscular force. Finally, the temper and judgment should be clear, the skill as great as possible, and the man should have the moral and physical force to fight to the last extremity of endurance. To secure these ends, the diet is restricted to lean and easily digestible meats, stale bread or toast, a small quantity of vegetables and a very moderate quantity of liquids; but the amount of food should be sufficient to satisfy the appetite, never allowing the nervous system to become depressed. The exercise is such as to develop the general muscular system, particularly the muscles employed in hitting, and the legs. To secure perfect condition of the nervous power, all sources of mental irritation are avoided and stimulants, if taken at all, are used with care and in small quantity. Tea may be used moderately once a day, without sugar or milk; a glass of sherry with a raw egg or a glass of old ale may be taken once a day, although it generally is best to avoid alcohol. It is of the greatest importance to secure perfect and tran-

quil sleep, which is a good indication of the condition of the nervous system.

If a man is in good health, purgatives, with which the training sometimes begins, are unnecessary. The bowels may be kept regular by varying the diet, and oatmeal gruel frequently is used with this end in view. Perfect action of the skin should be secured by proper ablutions after exercise. Fat may sometimes be removed from particular parts by local sweating with bandages. It is especially important to remove fat from the face and to harden the skin and subcutaneous cellular tissue, so that the "punishment" will not puff up the face, particularly about the eyes, which sometimes become closed by swelling under the blows of the antagonist.

A man is not in good condition unless the skin is bright, clear and free from blotches or pimples. A constitutional taint, such as syphilis, usually shows itself during a course of severe training, and the man breaks down or "goes stale." The wind and endurance are developed by boxing and running. The man boxes with his trainer or punches the bag for several hours each day, and runs at a moderate pace six to ten miles, doing sixty or hundred-yard dashes occasionally at top-speed. This shakes the abdominal organs, promotes the removal of fat from the omentum and gives play to the diaphragm, while at the same time it gives agility and power to the legs. The trainer should have his man under complete control, and should never leave him, night or day, during the whole course of training. He learns, if possible, the points and style of fighting of his adversary, and generally fixes upon a plan of battle. He boxes with his man constantly, hits him hard and accustoms him to bear punishment without loss of temper or judgment. His man should go into the ring confident that he will win the battle.

For at least twenty-four hours immediately preceding the fight the man should rest. Many trainers bring down the weight of their men by diet and sweating below the point at which they are to fight, depressing the system somewhat at first, and then allow the weight to come up to the proper point, so that they fight when the system is at its maximum of reaction and in perfect condition. In the articles of agreement of a prize fight, the weight at

which the men are to fight usually is stipulated. When no such stipulation is made, the men are said to fight at "catch weight," or at such weight as they may think proper. A man may fight at less than the stipulated weight, but he is ruled out if he is over weight. Pugilists are usually classed in regard to weight as follows: a man of one hundred and fifteen pounds or under is called a feather weight; between one hundred and fifteen and one hundred and thirty-three pounds, a light weight; between one hundred and thirty-three and one hundred and fifty-four pounds, a middle weight; at one hundred and fifty-four pounds or over, a heavy weight.

Boxing when practised for exercise and amusement or training for a prize fight, is conducted according to the rules of the ring, and the hands are provided with gloves padded with hair on the back to the thickness of two or three inches, so that the blows are less severe than with the naked fist. Glove fights are sometimes practised at public exhibitions, in accordance with pugilistic rules, and these are frequently quite severe. Occasionally the gloves are blackened so as to leave a mark when a man is hit, each blow being counted by the judges. This is called "boxing for points."

Boxing constitutes the greatest part of so-called pugilistic science; and different professors of the "manly art" usually have different methods or styles. The most important principles of boxing are the following: The position is with the left foot forward, the feet separated sixteen or eighteen inches, according to the size of the man. The weight rests mainly on the right leg, the left leg being free to advance. The body is erect, the head easily poised and erect so that the movements are free, and the hands are placed at about the level of the upper part of the chest, with the fists closed and the arms slightly bent. The left hand is somewhat in advance of and lower than the right, and is used mainly for striking when the antagonist is just within distance. The right hand is used in guarding blows of the left and in close work. A boxer keeps his eyes constantly fixed on the eyes of his opponent, ready to hit or guard when occasion offers. Sparring technically means the movements of the hands to and fro, which are constantly made when boxers are in position.

The main point in striking a first blow, or "lead-off," is to deliver the blow without any "show," or warning, and so quickly that the opponent can not avoid it. In boxing, feints are frequently made to direct the attention of the adversary from the place where the real blow is to be delivered. The blows of good boxers usually are struck straight from the shoulder; and the most effective blows are those into which the whole weight of the body is thrown. It is not correct judgment to strike a blow unless the distance and position of the opponent are such that the blow will probably "get in." A "chopping" blow is one in which the fist is brought from above downward. This blow is frequently used by good boxers in returns, but is not a good blow as a lead-off. The great point in striking is to hit quickly and as hard as possible. One solid blow is worth a hundred light taps. The most efficient blows are about the face and neck, on the pit of the stomach, and over the lower ribs. All blows below the waist are foul. Blows are avoided by guarding, jumping back, dodging with the head, etc. Dodging the head is very useful and is practised in making many of the so-called "points." A very slight movement of the arm upward in front of the face is sufficient to cause a powerful blow to glance off. A movement of the arm downward across the body wards off a body blow. In hitting, the large knuckles should strike, and the back of the hand should be turned outward. In real fights points are seldom used, and the practical work is done by plain hitting and guarding of the head and body.

The "counter" is a very effective blow, as it meets the man when he is advancing. This is a great practical point with good boxers. The man watches his opponent closely, and when he thinks he is about to lead off he strikes, hoping that his blow will get in before that of his adversary. At the same time he endeavors to guard his adversary's blow. A plain counter is when both men strike at nearly the same instant, with corresponding hands. If a man is remarkably quick in countering, he often demoralizes his adversary, who becomes afraid to make a full lead-off, fearing the counter blow. A man may counter either on his opponent's head or body. In countering, the opponent's blow is

sometimes avoided by dodging the head to one side. If the head is dodged backward, the force of the counter is lost, and the opponent may get in a severe blow in following up. When the opponent has received a heavy blow, it is well to follow up the advantage with close work and to keep the man moving, so that he has no time to recover himself. Close work, rapid blows at close quarters, or "fibbing," requires great skill and judgment. The blows in close work should always be straight, as they protect from the blows of the adversary. Such quick work, however, is a great strain on the wind and endurance. Right-hand work is very effective in close quarters. In making points the right hand is very useful. A man dodges his head to one side to avoid his opponent's lead-off with the left, and strikes his opponent with the right in the face (called a cross counter, because the right arm crosses the adversary's left) or he strikes his opponent in the body. Another point is to drop the head quickly under the arm of the opponent when he strikes, and to deliver blows right and left when the head is raised. Another point is to strike the opponent's left-hand blow aside with the palm of the left, and immediately strike with the right. Another is to strike the left-hand lead-off up with the left elbow, and strike immediately a chopping blow with the same hand ("peak and chop"). Other points such as those just mentioned are used, particularly in "fancy" boxing; but they can hardly be described clearly, even with the aid of illustration by drawings. Most of these "points" require great confidence, as the man advances to meet his opponent as he strikes, avoiding the blows mainly by dodging, or "head work."

There is no such thing as good boxing without a master. A boxer should have great practice and must box with many different persons. Clinching, chancery, and throwing are fair, so long as a man does not grasp his opponent's legs; but these manœuvres are not often practised in friendly boxing with gloves. A man steps in with his left foot, throws his left arm around the neck or chest of his opponent, and tosses him backward, the buttocks being crossed. This is called the "cross-buttock throw." Another throw is to step in with the right foot, throw the right arm around the opponent's waist, and throw him

over the hips (the "hip throw"). Many throws and trips are used in fighting, and each has its counter movement. Throwing in the ring differs from ordinary wrestling, as a man grasps his opponent wherever he can above the belt. The different kinds of chancery consist in rushing in when the opponent strikes, or in close quarters, and throwing either arm around his neck, striking him as hard and as often as possible in this position. Each chancery has its counter movement by which a man may sometimes extricate himself. The "upper cut" generally is used in close quarters. It consists in striking from below upward with the back of either hand, hitting the man under the chin or in the face, according to his position. Some boxers take a position occasionally with the right foot advanced instead of the left; but this position is not considered good, and it is much more difficult, with the right foot advanced, to protect the body.

See Egan, "Boxiana, a Sketch of Ancient and Modern Pugilism," 5 vols., London, 1818; Brandt, "Habet! A Short Treatise on the Law of the Land as it affects Pugilism," London, 1857; "Fistiana," 24th ed., London, 1863; Maclaren, "Training, in Theory and Practice," London, 1866; Harrison, "Athletic Training and Health," London, 1869; Flint, "Physiology of Man," vol. iii., p. 374 *et seq.*, New York, 1870; "The Slang Dictionary," London, 1870; and "American Fistiana, from 1816 to 1873," New York, 1874. "Bell's Life in London" contains accounts of the most important English prize fights, and Wilkes's "Spirit of the Times" (New York), of English and American fights. The "Spirit of the Times" for May 5, 1860, contains a full account of the fight between Heenan and Sayers.

Note.—The "Queensberry Rules," although drawn up shortly after the foundation of the "Amateur Athletic Club" in London in 1866, by Mr. John G. Chambers and the Marquis of Queensberry, were not adopted by professional pugilists at the time this article was written. They are now universally used in England and in the United States. Pugilists began glove-fighting for a certain number of rounds or "to a finish," for stake-money and purses, according to the Queensberry rules, in the United States, in 1877.

XLV

THE HABIT OF EXERCISE

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Almost any one can distinguish a boy or a man who is accustomed to proper physical exercise, by a certain ease and reserve power of movement and an erect and graceful bearing. Indeed, in a man there is no grace without strength and a good command of the action of muscles. Many laborers and hard-working artisans are powerful men in certain directions; but their work usually calls into action restricted sets of muscles and leads to unsymmetrical development and awkwardness. The same may be said of many acrobats and persons who perform special feats of strength.

I doubt if many of the readers of "The Companion" could wisely enter into competition with acrobats, and no one should attempt what are known as feats of strength before he has attained his full growth and development; but young persons, by judicious exercise, can lay the foundation for a life of physical vigor which one of indolent habit can never enjoy. I have often seen puny boys of twelve or fourteen years grow up under exercise into powerful, athletic men; and I venture to say that no one whose muscles have never been developed and who seldom if ever completely fills his lungs can feel the physical elasticity and animal exhilaration of absolutely perfect health.

The physical life of a child calls for little guidance. Days of almost unceasing activity and ten hours of sweet and dreamless sleep, with good and abundant food, make up the careless and happy life of childhood; but at the age of twelve or fifteen years, the intellectual and physical characters take more definite form and direction, and physical education becomes nearly as important as mental and moral development. The habits of life during the few

years of adolescence may develop either a vigorous and healthy man or one who, if not feeble, certainly is not robust.

How many are left behind in the struggle for existence and happiness, from physical weakness alone! Those who have the will and the strength to work while others are compelled to rest have a great advantage; and no strong intellect can attain the full measure of its capacity if burdened with a feeble and ailing body. Physicians often have occasion to recommend systematic exercise, but a grown man finds this one of the most difficult prescriptions to follow. A boy, however, if in good health, has a natural liking for exercise and takes kindly to gymnastics or athletics, especially if they are combined with amusement or if he is excited by emulation. With these advantages on the side of instructors, it is easy to give proper direction to physical training. The motto of a gymnasium where I have spent many hours during the last twenty-five years is, " Exercise, Health, Amusement." Exercise and amusement should go hand in hand; and health will take care of itself.

It is a safe general proposition that feats of strength and endurance are not for those who are young and growing. There is hardly any form of gymnastic or athletic exercise that does not develop and train the muscles and require strength; but lifting heavy weights, running long distances, or anything that carries fatigue to the verge of exhaustion is injurious to a person not fully developed. There is plenty to do without this: Vaulting, ladder exercises, single-bar, trapeze, suspended rings, parallel bars, light Indian clubs, light pulley-weights, rowing-machines —all these will give enough indoor exercise to develop the arms and trunk without heavy lifting or large dumbbells. Running short distances, jumping and tumbling, with the other exercises mentioned, will complete the muscular development.

With the examples of older gymnasts and proper instruction at the beginning, very little guidance is necessary, except for the more difficult feats and for tumbling. A competent instructor, however, is of great use, not only in teaching but in warning against danger. Few ordinary gymnastic exercises involve risk; but injury may occur to

an awkward beginner. Tumbling is one of the most amusing of indoor exercises and one of the best for general development; but this calls for competent instruction. Any one who can turn a running or standing front somersault, a back somersault, a "flip-flap," a "cart-wheel" and hold a hand-balance is sure to be well and symmetrically developed. None of these feats require much strength. This form of exercise is too much neglected in gymnasiums, probably because skilled instruction is indispensable; but those colleges in which tumbling is cultivated turn out the best and most evenly developed men.

No boarding-school or college is well organized without some sort of a gymnasium. During the many months in the year when it is impossible to exercise out-of-doors, a gymnasium is indispensable; and gymnastics are an excellent preparation for athletic exercises in the open air.

Boys and young men usually do not fancy callisthenics, regarding such exercises as effeminate or at least unmanly; but this form of exercise, and the name itself, which is made up of the two Greek words signifying beauty and strength, appeal to the weaker sex. Callisthenics are simply a form of light gymnastic exercise. The varied movements promote grace and lead to a moderate development of nearly all the muscles, without any great fatigue. While they are very useful, there is no good reason why girls should not take some of the more severe forms of gymnastic exercise. There are many movements with trapeze, suspended rings and similar apparatus requiring simply practice and address and but little strength, that might very well be practised by girls. But girls should never be allowed to lift heavy weights, use heavy dumb-bells, or make any sudden or violent exertion, for reasons which every physician can readily understand. Few women fail to cut a more or less ridiculous figure when they attempt to run; but running, when properly done, is one of the most graceful of physical exercises. Girls can easily be taught to run; and if they run well, their natural superiority in grace of movement over men will assert itself. From a purely physical point of view, dancing is admirable as a feminine accomplishment.

It is unnecessary to say that certain outdoor exercises are quite as useful to women as to men. A woman who

walks, rides, rows or plays tennis usually is one who enjoys good health; and callisthenics and light gymnastics are good preparations for outdoor sports. There are two forms of exercise now somewhat in vogue for women, that it is to be hoped will increase in popularity. These are fencing and swimming.

Fencing is one of the best of indoor exercises for general muscular development and cultivation of the eye and hand. If properly taught—and pupils should learn to fence with either hand—it calls into action nearly every muscle in the body. Furthermore, it is one of the few exercises with an antagonist, that is never rough and brutal and is not unmanly for a man or unwomanly for a woman. In fencing, address can successfully cope with brute strength. In an expert fencer, every movement of the exercise itself is one of grace; and the indefinable physical charm which comes of strength and habit of muscular exertion is ever present.

The other form of exercise, which can hardly be commended too highly, is swimming. Every boy and girl, man and woman should know how to swim, if for nothing more than its usefulness as an exercise and in promoting healthy action of the skin. Swimming is a light or a violent exercise as one may choose to make it. A good swimmer can exercise to the verge of exhaustion in one minute or can swim for an indefinite time. There is no reason why a swimmer, man or woman, should not be able to swim five or ten miles, except the loss of heat by long immersion in water.

Girls usually are not properly taught to swim. The main point is to learn in the beginning to swim with the least possible muscular effort, but to have all the effort tell in making progress through the water. When this has been accomplished, fast swimming, the different kinds of stroke, swimming under water, diving and all kinds of "fancy" swimming come naturally and easily. Swimming brings into play the entire muscular system and develops endurance and "wind"; and every good swimmer will say that of all athletic exercises, swimming is the one that gives most pleasure at the time and is followed by the most agreeable sense of physical satisfaction. But it is also true that its very merits are most likely to lead

to excess, and it should be practised with caution. At the very beginning of an undue feeling of chill or fatigue, the bather should come out of the water and secure a brisk reaction by rubbing.

In the case of any boy or girl without constitutional disease or deformity, even a small part of the exercises I have mentioned, taken for a short time each day or each alternate day, will develop, not only a healthy man or woman, but one in whom nearly every physical advantage is brought out. One can not imagine an awkward man or an ungraceful woman who can run, jump, ride, fence or swim well; and the brain does not work well and easily when other parts of the human mechanism are undeveloped or are rusty from disuse. Like most other good things, however, exercise may be overdone.

What is enough exercise? In the case of most of those who do not engage in manual labor, this question is unnecessary; but this remark applies to persons who have arrived at what are called years of discretion. Girls and boys, especially boys, may overdo, and the effects may be serious. A half-hour actually spent in moderate exercise in the gymnasium is not too little, and an hour is not too much. A time of the day should be selected when digestion is not in active progress. Beginners should be careful to avoid exercise to the extent of anything approaching a feeling of exhaustion; and a good reaction after a bath following exercise, with a feeling of moderate fatigue, that is by no means disagreeable, are indications that the exercise has been beneficial. For most persons, a cold shower or sponge-bath is the best; but this should not be taken until the perspiration is over and one has "cooled off," say ten or fifteen minutes after stopping work.

The immediate effect of muscular exercise is to increase the respiratory processes, promote oxidation and discharge of effete matters by the lungs, skin and kidneys and to raise the animal temperature. All this is natural; and this active discharge of fully oxidized effete matters diminishes or removes the liability to many diseases.

Soreness of muscles, even when considerable, is not necessarily an indication that exercise has been excessive. This is almost inevitable at the beginning, and if exercise

is persisted in, it passes off in a few days. Muscles when developing are always sore at first; but straining the ligaments of a joint is quite a different thing. Whenever a joint is strained, it should be kept at rest until recovery is complete.

It is impossible to set a limit, applicable to all, beyond which exercise is injurious. So long as it is taken with a certain degree of physical enjoyment and does not diminish the capacity for brain work, and so long as one eats, sleeps and feels well, exercise is not overdone. Systematically taken by the young, it gives the best chance for full and normal development; and in a grown man or woman, even fifteen or twenty minutes a day in a gymnasium or working with simple apparatus at home will keep the body in good condition.

In early life one can form habits of study and thought which are invaluable and can with difficulty be acquired in later years. So it is with the muscular system. If the habit of exercise is begun early and is prolonged into manhood or womanhood, it is easy enough to keep well and strong.

XLVI

ON THE CAUSE OF THE MOVEMENTS OF ORDINARY RESPIRATION

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THE movements of ordinary respiration, which begin at birth and continue uninterruptedly throughout the life of man and of all warm-blooded animals under normal conditions, have an exciting cause. This cause, whatever it may be, does not operate during the period of intra-uterine existence; and it is well known to physiologists that the part which the lungs play after birth in the introduction of oxygen is performed in the fœtus by the placenta. If the umbilical vessels are compressed in a living animal the fœtus will soon begin to make respiratory efforts; and this even at an early stage of development. This experiment is by no means new and it is one that I have often repeated. Another instructive observation, illustrating the same principle in adult animals, was made in 1664 by the celebrated Robert Hooke. In this experiment it was ascertained that if air is efficiently supplied to the lungs of a living animal by artificial respiration, as by fixing a bellows in the trachea and regularly inflating the lungs at short intervals, respiratory efforts will soon cease and the animal will remain quiet so long as the artificial supply of air is properly maintained.

In the first of the experiments just mentioned, movements are apparently excited because the respiratory function of the placenta is interrupted; in the second, the normal respiratory movements are arrested, as it seems, because the exciting cause of these movements is temporarily removed. The explanation of the phenomena observed in both experiments involves the assumption of the existence of some exciting cause or of a demand on the part of the system which secures in the adult animal the

regular and periodic introduction of fresh air into the lungs. In normal, tranquil respiration this cause operates independently of sensation. When there is any deficiency in the supply of fresh air, one experiences a sense of respiratory difficulty or it may be exaggerated to the point of a feeling of impending suffocation. This sense, both normal and exaggerated, might properly be described as the sense of want of air, or as it is called by the French, "besoin de respirer." Many years ago (about 1809) Legallois showed that animals instantly ceased to breathe when the medulla oblongata was destroyed. In 1823 and 1827 Flourens clearly defined a certain portion of the medulla oblongata, near the origin of the pneumogastric nerves, as the respiratory nerve-centre. These experiments and those made subsequently by other physiologists demonstrated that a nerve-centre situated in the medulla oblongata is the only part capable of appreciating the sense of want of air. When this part is destroyed respiratory movements instantly cease, for the simple reason that the nerve-centre which alone is capable of receiving the impression due to want of air is destroyed. About 1833 the attention of physiologists was directed by Marshall Hall to what are now known as reflex phenomena. He regarded the respiratory movements as reflex, depending on an impression conveyed to the medulla oblongata through the pneumogastric nerves, received by the medulla oblongata and reflected back through certain motor nerves to the muscles of inspiration.

This brief historical sketch, in which only the most important of the many experiments made on the subject under consideration have been mentioned, serves to show the state of knowledge up to a time a few years later than the observations of Marshall Hall.

In following out the question of the cause of the respiratory movements, it is necessary to appreciate as exactly as possible the mechanism of the appropriation of oxygen by the system.

With each inspiratory act about twenty cubic inches of fresh air are taken into the respiratory organs to replace about the same quantity of vitiated air expelled in expiration. The air thus introduced is lighter than the air contained in the deeper part of the lungs, the latter

being charged with carbonic acid. It is evident, however, that little if any part of the twenty cubic inches of fresh air can immediately reach the air-cells, in which the interchange of gases between the air and the blood actually takes place, for the lungs ordinarily contain about two hundred cubic inches; but in accordance with the law of diffusion of gases, there is a constant progression of the air, laden with carbonic acid, from the deeper parts of the lungs toward the trachea, and an equally constant penetration of the fresh air toward the air-cells. In this way, although the fresh air is introduced and the vitiated air is expelled intermittently about eighteen times per minute, the contents of the air-cells probably present a nearly constant composition as regards oxygen and carbonic acid; the supply of oxygen being maintained by the repeated inhalation of fresh air, and the blood, in its passage through the pulmonary capillaries, constantly giving off carbonic acid. It is only when the supply of oxygen is deficient that one is actually conscious of a sense of want of air.

There is a corresponding regularity in the current of blood through the capillary vessels in the walls of the air-cells. The heart contracts intermittently about seventy times per minute; but the successive charges of blood that are sent by the right ventricle into the pulmonary artery are received by vessels of great elasticity, which, as it were, absorb the intermittent force of the heart, so that the current which passes through the capillary vessels of the lungs is of constant and uniform rapidity. The venous blood thus passing through the lungs is constantly exhaling carbonic acid into the air-cells and receiving oxygen. The oxygen thus taken up by the blood immediately forms a union with the coloring matter of the blood-corpuscles, the blood becomes oxygenated, or arterialized, and is distributed to the system through the branches of the aorta. As the blood passes into the capillaries of the general system the same cause which secures a constant and uniform current of blood through the pulmonary capillaries; viz., the elasticity of the arteries, produces a constant and uniform flow of blood, which gives up its oxygen to the tissues and passes into the veins, laden with carbonic acid. The lungs simply serve to present oxygen

to the blood; and the blood is the vehicle by which oxygen is carried to the tissues; true respiration, however, consists in the appropriation of oxygen by the tissues and is constantly going on in every highly organized part in the economy.

The theory of Marshall Hall, that respiratory movements are excited by the accumulation of carbonic acid in the lungs, the impression thus produced being conveyed to the medulla oblongata by the pneumogastric nerves, is disproved by the fact that these movements continue, although modified, after section of the pneumogastrics in the neck; and as early as 1839 John Reid suggested that the sense of want of air was due in a measure to the circulation of venous blood in the medulla oblongata itself. In 1841 Volkmann made a number of experiments, from which he concluded that the respiratory movements were reflex in their character, but were due to the stimulation by carbonic acid of afferent nerves in every part of the body. Without entertaining any doubt in regard to the reflex character of the respiratory movements, I made, in 1861, a series of experiments in which I endeavored to show that the sense of want of air was due to want of oxygen in the general system and not to the stimulation of afferent nerves by carbonic acid. In these experiments I first showed that in living animals, after the respiratory movements had been arrested by artificial respiration, respiratory efforts began, when artificial respiration was interrupted, only when the blood became dark in the arteries. Recognizing the fact that oxygen can reach the tissues only through the blood, I drained the animal of blood, still keeping the lungs supplied with air, and always succeeded in this way in exciting respiratory movements. The views which I then entertained were still further supported by experiments made by Pflüger, in 1868, who excited respiratory movements in animals by insufflating the lungs with an irrespirable gas, such as pure nitrogen.

Having often repeated my experiments since 1861, frequently as class demonstrations, it occurred to me in 1877 that possibly the respiratory movements might be due to some direct change in the conditions of the medulla oblongata; and I began to entertain doubts in regard to their reflex character. I then undertook a series of experiments

which led me to the conclusion that the sense of want of air is due to the want of oxygen in the medulla oblongata itself. The general results of these experiments, the details of which have been published elsewhere, were as follows:

In a dog brought fully under the influence of ether, artificial respiration was established, by means of a bellows fixed in the trachea, so completely that all respiratory efforts on the part of the animal ceased. The innominate artery and the left subclavian artery were then exposed so that the vessels could be constricted at will. The irritability of the medulla was tested by interrupting artificial respiration, which was followed by respiratory efforts. Then, artificial respiration having been resumed so that the animal remained perfectly quiet, the great vessels given off from the arch of the aorta were constricted, the artificial respiration being continued. This was invariably followed by violent respiratory efforts, which began in a little more than two minutes after constriction of the vessels and continued until the vessels were freed, when the efforts ceased. No such phenomena followed constriction of the aorta below the arch, which of course shut off the blood from all parts of the body except the head and anterior extremities. The experiments of which this is an example were frequently repeated, always with the same results. If it is assumed that the medulla oblongata is the sole respiratory nerve-centre, it is reasonable to suppose that the occlusion of the vessels given off from the arch of the aorta, which cuts off the supply of oxygenated blood from the medulla, gives rise to a sense of want of air by reason of some change in the conditions of the medulla, which conditions are again changed so soon as blood is allowed to flow again through these vessels.

Reasoning from the facts developed by my own experiments, taken in connection with what is well known and established in regard to the action of the medulla as a respiratory nerve-centre, the following seems to be a satisfactory explanation of the mechanism of the ordinary respiratory acts:

The left ventricle sends arterial blood received from the lungs to all parts of the system, including the medulla oblongata. The elasticity of the aorta and of its branches

gradually extinguishes or absorbs the intermittent force of the heart so that the blood flows in a steady and continuous stream through the capillaries of the medulla. But as the tendency of the air in the pulmonary cells is to progressively increase in its proportion of carbonic acid and to diminish in its proportion of oxygen between two respiratory acts, the tendency of the blood coming from the lungs and sent by the left ventricle to the medulla oblongata is to become progressively poorer in oxygen. After about four revolutions of the heart, assuming that the relation of the beats of the heart to the respiratory acts is four to one, the quantity of oxygen supplied to the medulla oblongata has become so far diminished that there occurs an unconscious sense of want of air, and this excites a new inspiratory act. So it is, in all probability, that the normal rhythmical acts of inspiration are periodically excited; and anything, like violent muscular exercise, that increases the activity of the consumption of oxygen of necessity increases the number of respirations per minute.

When there occurs any serious interference with the passage of fresh air to the air-cells or an obstruction to the flow of arterial blood to the medulla oblongata, as in certain pulmonary and cardiac diseases, the unconscious sense of want of air is exaggerated until one becomes conscious of pulmonary oppression or impending suffocation. This is simply an exaggeration and extension of the normal respiratory sense so that it reaches the true sensory centres, causing a voluntary increase in the number and extent of the respiratory acts. The sense of suffocation, indeed, differs from the normal respiratory sense merely in degree and in the fact that the former operates on the centres of ordinary sensation, while the latter is confined to the medulla oblongata.

When respiration has been so long obstructed that respiratory efforts cease, the medulla rapidly loses its capacity to appreciate the sense of want of air; still, under these circumstances, if the heart continues to beat, artificial respiration, if persisted in so as to restore the supply of arterial blood to the medulla, will often restore the sensibility of the respiratory nerve-centre, so that finally the respiratory movements will become reëstablished.

Physiologists who are in the habit of administering anesthetics to animals have frequent occasion to note this fact. A dog, for example, becomes so overpowered by an anesthetic that the sensibility of the medulla is for the time destroyed and respiration is arrested; the heart, however, continues to act, although its contractions are feeble; but artificial respiration, if kept up efficiently and persistently, will maintain the action of the heart, the respiratory sensibility of the medulla gradually returns and after a time the respiratory movements return.

Narcotics also may affect the respiratory sensibility of the medulla so that the frequency of the respiratory acts is diminished and they may be arrested; and in such instances it is sometimes possible to revive the respiratory function by artificial insufflation of the lungs. In most cases of suspended respiratory action from any temporary cause, although electricity, sudden and active stimulation of the surface, etc., may aid in restoration, the main reliance should be on persistent and efficient artificial respiration.

ARE THE NORMAL RESPIRATORY MOVEMENTS EITHER ENTIRELY OR IN PART REFLEX, IN THE SENSE IN WHICH THE TERM REFLEX IS ORDINARILY UNDERSTOOD BY PHYSIOLOGISTS?

I shall leave out of this question various modifications of the respiratory acts, such as coughing, sneezing, etc., and the influence of certain unusual impressions made upon the general surface, as by a cold douche, and restrict the discussion to the phenomena of ordinary respiration. Experiments have shown that the unconscious and automatic movements of respiration in an animal may be arrested by artificially supplying the lungs with fresh air, which has the effect of securing to the capillaries of the medulla oblongata, as well as of other parts, a sufficient quantity of oxygenated blood. This supply of oxygen through the blood removes the exciting cause of the respiratory movements by abolishing for the time being the sense of want of air. When, however, there is a deficiency in the supply of oxygen to the medulla, this deficiency gives rise to a sense of want of air, and respiratory efforts

follow. The quantity of blood sent to various parts of the body is subject to frequent variations through the influence of the vasomotor nerves on the muscular coat of the arteries; in other words, these nerves may modify and regulate local circulations independently of the action of the heart; but the circulation in the medulla oblongata seems to be the physiological gauge of the requirements of the general system for oxygen; and it is by virtue of this property that the medulla is enabled to act as the respiratory nerve-centre. Every vascular part of the body requires oxygen, a proper supply of which is necessary to its nutrition and to the performance of its functions. Normal variations in nutritive or functional conditions may and do involve in certain parts great modifications in the supply of blood, which modifications are regulated by vasomotor nerves; but these variations in the local circulations do not usually produce impressions capable of modifying the respiratory acts, unless they are attended with an actual increase in the quantity of oxygen consumed in the organism. In case the consumption of oxygen is increased from any cause, the quantity supplied by the lungs must also be increased in order to keep the proportion of oxygen in the arterial blood at the proper standard. The respiratory nerve-centre seems to take cognizance promptly of any deficiency in the supply of oxygen to its substance, and it measures by this deficiency the respiratory demands of the system. With a knowledge of the results of recent experiments, one can hardly imagine that the different parts of the organism, possessing, as they do, such a variety of functions and properties and subject to such modifications in the supply of blood which they receive, can all be endowed with a common sense which may be conveyed to the medulla oblongata and there appreciated as the sense of want of air. In view of the variations to which the circulation in special parts is subjected, it would seem that a confusion of impressions must necessarily result if these impressions originated in the general system. It is only in the pulmonary structure, indeed, that such an impression could arise; but this is not the fact, for the following reasons: Respiratory movements occur when the nervous connection between the lungs and the medulla has been severed. When the

supply of oxygenated blood to the medulla has been cut off, respiratory efforts occur, even though the lungs are fully supplied with air and no deficiency of oxygen or excess of carbonic acid can exist in the air-cells.

Taking into consideration all the facts bearing upon the question, I can come to but one conclusion in regard to the character of the movements of normal, tranquil respiration:

When perfectly normal and not modified by any unusual physical conditions, the regular acts of tranquil respiration are not reflex, at least in the sense in which the term reflex is ordinarily understood by physiologists. As I have said before, there is a constant and uniform current of arterial blood to the medulla oblongata, and there is a progressive diminution in the proportion of oxygen in the blood between the respiratory acts. After a certain time the supply of oxygen to the medulla becomes so far reduced that it gives rise to an unconscious sense of want of air, which excites an act of inspiration. This repeats itself regularly eighteen to twenty times in a minute. Under these conditions, regular respiratory movements are excited by a stimulus generated in the medulla oblongata itself and depending solely on the state of the circulation in this part.

NORMAL MODIFICATIONS OF THE RESPIRATORY MOVEMENTS BY REFLEX ACTION

Although regular movements of respiration may go on without any action that can strictly be called reflex, reasoning in regard to respiration from the phenomena observed in connection with other important functions, one would naturally expect to find the process by which oxygen is introduced into the body subject to modifying and regulating influences operating through the nervous system. The action of the heart is automatic; but the force and frequency of the contractions of this organ are controlled more or less, under physiological conditions, by the nervous system. The connection between aëration of the blood and the circulation is certainly very close; physiological conditions must frequently occur which demand changes in the rapidity and extent of respiratory

acts without involving voluntary effort or even consciousness; and many of these demand the intervention of nervous action aside from the mere development of the sense of want of air in the medulla oblongata. Admitting the truth of these propositions as regards tranquil respiration, it is well known that important physiological reflex influences upon the acts of respiration operate through the pneumogastric nerves.

A relatively strong electric current applied to either the pneumogastric nerves in the neck or to certain branches of the pneumogastrics (the superior and the inferior laryngeals) will instantly arrest respiration. This action is reflex, as is shown by the fact that stimulation of the central ends only, of the divided nerves, influences respiration. The fact just stated is marked and constant; at the same time it has been noted that stimulation of certain other sensory nerves will arrest respiration, although this result is not invariable. When the respiratory movements are completely arrested by faradization of the pneumogastrics, it is always the same for the general movements of the animal. On the other hand, "a feeble excitation accelerates respiration; a more powerful excitation retards it; a very powerful excitation arrests it. These words 'feeble' and 'powerful' having, it is understood, only a relative sense for any one animal and under certain conditions: what is feeble for one would be powerful for another." (Bert.)

So far as these experimental facts can be applied to the physiology of ordinary respiration, it seems that the nerves, the action of which is brought into play under physiological conditions, must be mainly if not exclusively the pneumogastrics. These nerves have their origin at the medulla oblongata; they are distributed to the entire respiratory apparatus, from the larynx to the deepest parts of the lungs, but not to the respiratory muscles, except the intrinsic muscles of the larynx; and they are capable, by reflex action, of exerting a very marked influence over the respiratory movements.

It is important in this connection to note another experimental fact in regard to the pneumogastrics. When both nerves are divided in the neck, the irritation directly produced by their section momentarily accelerates the re-

spiratory movements. In animals in which the walls of the larynx are sufficiently rigid to enable the acts of inspiration to be carried on without any serious obstruction, the following phenomena are observed: For a few seconds rapidity of the respiratory movements may be increased; but so soon as tranquillity is restored, the number of respirations per minute is very much diminished, falling from sixteen or eighteen to four or five, and the inspiratory acts become unusually profound and are attended with excessive dilatation of the thorax.

The respiratory phenomena following stimulation and section of the pneumogastrics in the neck have never been satisfactorily explained; and certainly an explanation would throw some light on the reflex action of these nerves in normal respiration. If, however, my view of the action of the medulla oblongata in tranquil respiration can be accepted, a very interesting proposition made by Rosenbach, in 1878, renders it possible to present a theory which, while it may not be entirely satisfactory, is interesting and suggestive and may be sustained by future experimental researches. Rosenbach advanced the idea that the pneumogastrics are the vasomotor nerves of the medulla oblongata and that they contain fibres which contract and fibres which dilate the bloodvessels. This is presented merely as an hypothesis, which he " hopes later to be able to establish by experiments."

If it is assumed, for sake of argument, that the pneumogastrics actually contain fibres which regulate the supply of blood to the medulla oblongata, it would be easy to understand how such fibres could so influence the supply of oxygen to the respiratory nerve-centre as to secure such a succession of respiratory acts as would be demanded by the system under different physiological conditions; still, the seat and the exact nature of the impressions giving rise to reflex changes in the calibre of the vessels of the medulla would be a matter of speculation and conjecture.

Applying the suggestion made by Rosenbach to experiments on the pneumogastrics, the phenomena observed could be explained as follows:

Relatively feeble electric stimulation of the pneumogastrics accelerates respiration by contracting the vessels

of supply to the medulla and thus diminishing the supply of oxygen.

Powerful stimulation of the pneumogastrics arrests all movements in animals, including the respiratory movements.

When the action of the medulla is removed from the influence of the pneumogastric nerves, as it is after division of both nerves in the neck, air is taken into the lungs when the deficiency of oxygen in the medulla has reached the point at which the sense of want of air necessarily generates the stimulus sent to the inspiratory muscles. This action is in no sense reflex, and it depends entirely upon the development of a stimulation or an irritation in the medulla itself. Under these conditions the acts of inspiration are abnormally infrequent and they become excessively prolonged and profound. It is probable that death occurs in a few days after this operation, not alone from abnormal respiratory action, but from a suspension of other important functions of the pneumogastrics. It is possible, also, that some of the phenomena observed in narcotic poisoning—notably a great diminution in the frequency of the respiratory movements—may be due in part to interference with the respiratory functions of the pneumogastrics.

So far as muscular action in tranquil respiration is concerned, I have thought it necessary to consider only the acts of inspiration; for expiration is produced mainly by the passive contraction of the capacity of the thorax and by the resiliency of the elastic pulmonary parenchyma succeeding the action of the muscles which enlarge the chest and inflate the lungs.

The results of my experiments, observations and reflections on the cause and nature of the movements of normal respiration may be embodied in the following propositions:

1. The respiratory sense, "besoin de respirer," sense of want of air, or the stimulus which gives rise to respiratory efforts, is due to a deficiency of oxygen in the medulla oblongata, which is the sole respiratory nerve-centre.

2. In perfectly tranquil, uniform and undisturbed respiration, the regular and successive inspiratory acts may go on in obedience to successive stimuli, originating in

the medulla oblongata. Such respiratory movements are not reflex.

3. The frequency and the extent of the normal inspiratory movements are regulated and accommodated to the physiological requirements of the system by reflex action operating through the pneumogastric nerves.

XLVII

THE BREATH OF LIFE

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Man comes into the world with a cry, not of joy or of pain or of fear, but a vocal sound announcing that a being has taken the first breath of life, and that a new independent existence is begun.

This cry attends the beginning of a new group and series of phenomena. Certain of the great blood-currents through the heart are instantly changed in their course. A cold-blooded animal, virtually, with a mixture of venous and arterial blood circulating through a great part of the body, becomes, with the first breath, a warm-blooded animal; the single heart becomes a double heart, one side sending blood to the lungs, and the other side, to the system at large; all the so-called vital processes take on an increased activity; there begin at that moment vigorous muscular movements; the special senses, especially sight and hearing, are rapidly developed; the new being can digest, feel, smell and taste; and finally, intelligence begins to dawn. All these changes begin with the first act by which air is taken into the lungs.

Nearly every important function in the body is dependent, directly or indirectly, on respiration. Without circulation of the blood, there can be no digestion, no absorption, secretion or nutrition. Without respiration there can be no circulation of the blood; and without circulation there can be no respiration.

It is an error to suppose that the mere entrance of air into the lungs constitutes respiration. A man may suffocate although his lungs are abundantly supplied with fresh air. Persons with extensive valvular disease of the heart which impedes circulation suffer from a sense of want of air, even though the action of the lungs is perfect. In

order to respire, the air must first be inhaled; and the blood passing through the lungs takes up the oxygen and carries it to every part of the body. Circulating in the capillary bloodvessels, some of which are not more than one-six-thousandth of an inch in diameter, oxygen is taken up and used by every highly-organized tissue and organ of the body. This appropriation of oxygen by the tissues really constitutes respiration, and the taking of oxygen into the lungs and its absorption by the circulating blood are simply the means of conveying oxygen to the parts; but this demand on the part of the tissues for oxygen is imperative; and life continues for but a few minutes after the supply of oxygen is cut off.

Up to the time of Lavoisier (about the year 1776) physiologists had no definite notion of the mechanism of respiration; and the first statement pointing to the idea that the air taken into the lungs did anything more than cool the blood was made by Leonardo da Vinci, in the latter part of the fifteenth century. In 1776 Priestley discovered oxygen. At about the same time Lavoisier noted the consumption of oxygen in respiration and the discharge of carbonic acid by the lungs. From 1776, the year of the discovery of oxygen, dates our first knowledge of the composition and the uses of the air in respiration.

It was shown by Boyle, the founder of the Royal Society of London, in 1670, that air is necessary to the life of all animals. Animals that live under water require air, which they obtain from the water holding air in solution. It must be interesting, therefore, and it certainly is useful to study the processes by which every part of every living being is supplied with oxygen.

The air we breathe is composed of a mechanical mixture of oxygen and nitrogen, in the proportion of one part of the former to about four parts of the latter. Oxygen is the only agent concerned in respiration, the nitrogen simply serving to dilute the respirable gas. A man takes a fresh supply of air into the lungs about eighteen times per minute. The lungs contain usually about two hundred cubic inches of air; but only about twenty cubic inches are changed with each respiratory act.

These acts of respiration are essential to life. They

begin with the beginning of our independent existence, and they continue uninterruptedly to the end. Sleeping or waking, sensible or insensible, the acts of respiration go on. The conditions of our existence require that we shall be able to modify the respiratory acts, as in speaking, singing, blowing, etc.; but although we can hold the breath for a time, we can not arrest the breathing permanently by a voluntary effort, any more than we can forget to breathe.

There is provision in the nervous system by which the acts of respiration are maintained in their normal frequency. Just beneath the brain, and at the very beginning of the spinal cord, in what is called the medulla oblongata, is a little collection of nerve-cells which preside over the respiratory movements. When these cells are injured respiration instantly ceases.

Thanks to recent experiments, the mechanism of the influence of the medulla oblongata over respiration is now fairly well understood. This part of the nervous system, like other parts, is supplied with arterial blood, which contains oxygen. When the oxygen in the blood circulating through the medulla oblongata is diminished in quantity, an involuntary impulse is sent to the muscles which dilate the chest, and fresh air is taken into the lungs. When the oxygen thus taken in begins to be consumed, another impulse is sent out and another inspiration takes place.

These impulses occur about eighteen times per minute, or as often as we respire; and they keep the body supplied with the proper quantity of oxygen. They usually are unconscious and involuntary; and this is the reason why the ordinary acts of respiration are involuntary and continue even when we are unconscious.

Suppose, however, that there is a deficiency of fresh air, and that there is danger of suffocation! The unconscious impression normally made upon the medulla oblongata becomes exaggerated and is conveyed to the brain, where it is recognized as a sense of suffocation. We then feel most acutely the sense of want of air and make violent voluntary efforts to breathe. If these are unsuccessful, we soon become insensible and die of asphyxia.

The gentle movements by which the air is insensibly changed in the lungs are accomplished by the action of

muscles which raise the oblique ribs and increase the width and depth of the chest, and a descent of the diaphragm, which increases its vertical diameter. The diaphragm is a muscle lying between the chest and the abdomen; and as it contracts it draws the elastic lungs downward. With each movement of inspiration, about twenty cubic inches of fresh air are drawn into the lungs. But the oxygen passes into the blood through the thin coat of the capillary bloodvessels in the air-cells situated in the deepest parts of the lungs; and if the lungs have a normal capacity of two hundred cubic inches and only twenty cubic inches of fresh air are taken in with each respiratory act, how is it that the fresh air is enabled to get to these air-cells?

This is explained by what is known as the law of diffusion of gases. If we open a bottle of ammonia, for example, the vapor diffuses in the surrounding air and is recognized by the sense of smell. Such a process of diffusion takes place very rapidly in the air in the lungs. The air-cells are constantly receiving from the blood a heavy, irrespirable gas, carbonic acid; and the vitiated air is constantly diffusing itself outward, the fresh air taking its place by diffusion toward the air-cells. It is in this way that carbonic acid is constantly thrown off by expiration and oxygen is supplied to the blood. But a small proportion of the oxygen taken in at each inspiratory act is absorbed in the lungs. Assuming that twenty cubic inches of air are inspired, this contains four cubic inches of oxygen, of which one cubic inch only is taken up by the blood.

Expiration, or the expulsion of air from the lungs, is normally a passive process and is due to the reaction of the elastic walls of the chest and of the elastic tissue of the lungs after the contraction of the muscles which have dilated the chest ceases; but by voluntary efforts, we can draw the walls of the chest downward and press the diaphragm upward by contraction of the abdominal muscles, so as to produce the acts of blowing, singing, etc.

The air-cells of the lungs are little vesicles measuring from one two-hundredth to one-ninetieth of an inch in diameter; and in the deepest portions of the lungs, the air is separated from the blood by an excessively thin and permeable membrane, the single coat of the capillary bloodvessels. The blood contains millions of minute red

corpuscles, which have a remarkable affinity for oxygen. These corpuscles seize upon the oxygen of the air but absorb little or no nitrogen. The oxygen thus absorbed forms a union with the coloring matter of the corpuscles and is carried on by the circulation to every part of the body. Every tissue and organ of the body needs oxygen. These parts, then, take up the oxygen carried to them by the blood-corpuscles and give off carbonic acid gas. This carbonic acid is taken up by the clear liquid of the blood in which the corpuscles float, is carried back to the lungs and is there discharged in the act of expiration. When the blood loses its carbonic acid and takes up oxygen in the lungs, it always changes from a dark blue to a vivid red. The following experiment, which I make every year as a demonstration to a medical class, illustrates this change: If we take out the lungs from an animal just killed, we can imitate, by means of a bellows, the acts of respiration. If we now inject through the lungs dark, venous blood, it gives off carbonic acid and takes up oxygen, as it does during life; and as it comes from the lungs, it has a brilliant red color.

From what has been stated above, it is evident that the real and essential processes of respiration take place, not in the lungs, not in the blood, but in the tissues themselves. When a bit of living muscle is placed under a bell-glass containing air, it absorbs oxygen and actually breathes, without the intervention of lungs or even of blood. An animal dies of suffocation when the blood-corpuscles, which carry oxygen to the tissues, are paralyzed by poisoning with carbonic oxide gas, when the greatest part of the blood is drawn from the body or when the great bloodvessel (the aorta) which supplies the body is tied, in essentially the same way as when strangled by a rope tied around the neck.

How remarkable has been the progress of knowledge of ourselves within a little more than a single century! We knew little of physiology, because we did not know of the circulation of the blood, until early in the seventeenth century; but how little did we know, even after Harvey had taught the circulation, until the year 1776, when Priestley discovered oxygen and Lavoisier showed that oxygen really constitutes the breath of life!

XLVIII

THE MECHANISM OF THE SINGING VOICE

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It does not require more than a general idea of the anatomy of the vocal organs to enable one to comprehend the mechanism of the production of the voice. Teachers of singing should know how the singing voice is produced and especially how it passes from one register to another. To a clear understanding of this, a knowledge of the mechanism of the different vocal registers is indispensable. Many fine voices have been ruined by teachers endeavoring to train the vocal organs in accordance with crude and vicious theories or with no knowledge of the vocal mechanism. Pupils can work to more advantage if they have a definite idea of proper methods of vocal training. It adds greatly to the appreciation and enjoyment of vocal music to understand the processes by which the musical effects are produced; and legitimate art is encouraged by public appreciation of the results of honest and intelligent work. These considerations have induced me to write this article, in the hope of contributing something to a general knowledge of vocal mechanism.

The voice is produced by vibrations of ligamentous bands situated at the top of the larynx. These bands have a direction from before backward, having their ends closely approximated in front and there fixed. They are attached behind to movable cartilages, which may be brought together or somewhat separated at will, or which may be carried backward by muscular action, producing varied degrees of tension. These bands are the true vocal chords, and these alone are concerned in the production of the voice. Above these two chords are two bands (the so-called ventricular bands) a little more widely separated from each other, sometimes called the false vocal chords,

as they take no part in vocal vibrations. The larynx, then, by virtue of the true vocal chords, is a musical instrument.

The muscular mechanism by which the vocal chords are stretched to different degrees of tension is not of so much importance as are the results of this action, observed in the position and relations of the vocal chords and the characters of the vocal sounds produced. The most important of these muscles are concealed within the larynx. They are not increased in size to any considerable extent by exercise, owing to the limited capacity of the cavity of the larynx. They may be strained or enfeebled by over-use or injudicious training, and then the vocal organ seems to suffer irremediable damage. A strained or a badly worn voice never regains its original power, freshness or sweetness; but a voice carefully and properly trained, if not abused, will retain its qualities for many years.

During the ordinary movements of respiration the larynx is nearly passive; but during forced inspiration the vocal chords are separated at their posterior attachments and the larynx is widely opened. When a vocal sound is to be produced, the chords are put upon the stretch and the larynx is closed, to be partly opened by the expiratory effort. The vocal chords are thus prepared in advance for the note that is to be emitted, and are thrown into vibration by a current of air forced through the larynx by the muscles of expiration. The chords vibrate when the air is forced out of the windpipe; and proper regulation of the breath is of great importance in singing.

As in nearly all musical instruments, the actual vibrations of the vocal chords are reinforced by resonant cavities. The air in the larynx itself, the windpipe, pharynx, mouth and nasal cavities reinforces the vibrations and modifies the power and quality of the voice. The most important modifications of vocal sounds are produced by resonance of air in the pharynx, mouth and nasal cavities; and this resonance is indispensable to the production of the natural human voice. A muscular curtain (veil of the palate) hangs between the cavity of the mouth and the posterior cavities of the nose. This may pass backward so as to close the openings into the nasal cavities, and

the tongue may move backward so as to diminish the capacity of the cavity of the pharynx. As notes made by vibrations of the vocal chords mount higher and higher in the musical scale, the tongue is drawn back, its point is curved downward, its base projects upward and backward and the cavity of the pharynx is diminished in size. At the same time the muscular curtain (veil of the palate) is constricted and moved backward, until, in the highest notes of the chest register in the male and the upper medium in the female, the openings into the nasal cavities are closed and the resonance is mainly in the bucco-pharyngeal cavity. When, however, a singer passes into what is sometimes called the head voice (falsetto), the veil of the palate is drawn forward instead of backward, and the resonance takes place chiefly in the naso-pharyngeal cavity. In moderately low chest notes all the cavities resound. The larynx itself moves upward for high notes and downward for low notes, and there is some resonance of air in the windpipe.

The movements of the tongue, mouth, veil of the palate and larynx are important in vocal efforts. These are properly taught by all good teachers of singing, who have learned their mechanism by experience. The uvula, hanging from the middle of the veil of the palate, is important in the closure of the nasal openings. The leaf-like cartilage which stands erect in front of the larynx may be moved backward, mainly by pressure from the base of the tongue, and is useful in modifying the form of the cavity just above the larynx. Faulty action of any of these parts may easily be remedied; and it is not likely permanently to injure the voice like faulty management of the muscles which act on the vocal chords.

The movable cartilages to which the posterior ends of the vocal chords are attached are called the arytenoid cartilages. These will be mentioned frequently in connection with the mechanism of the different vocal registers.

The laryngoscope is an instrument by means of which the movements of the vocal chords may be observed and studied. It consists simply of an arrangement of mirrors under proper illumination, by which the vocal chords are brought into view. Manuel Garcia was the first to use

this instrument, studying the mechanism of vocal movements in his own person. His observations were published in the "Proceedings of the Royal Society," in 1856. Since then similar observations have been made by Mrs. Seiler and by many scientific investigators. The observations, however, of Garcia and Mrs. Seiler, both professional singers and teachers of singing, are peculiarly valuable.

In studying the action of the larynx in the different vocal movements, one difficulty at the very beginning is in fixing upon clear definitions of what are recognized as vocal registers. In the first place it must be recognized that the singing voice is different from the speaking voice. Without appearing to be actually discordant so as to offend a musical ear, the ordinary voice in speaking never has what is strictly called a musical quality; while the perfect singing voice produces true musical notes. This probably is due to the fact that the inflections of the voice in speaking are not in the form of distinct musical intervals, that the vibrations follow each other and are superimposed in an irregular manner and that no special effort is made to put the vocal chords upon any definite tension, unless to meet an effort when the voice is increased in force. A true musical note or tone is composed of mathematically regular vibrations in definite numbers for each note. A noise is composed of irregular vibrations. Two or more musical notes are in harmony when the vibrations blend and do not interfere with each other. They are discordant when they oppose each other; at certain times producing, by such opposition, short intervals of silence, technically known as "beats." A shout or a scream is quite different from a powerful singing note. No good singer shouts or screams, although such noises are sometimes heard in what is called singing. The difference between the speaking and singing voice is at once apparent in contrasting recitative with ordinary dialogue in operatic performances.

The divisions of the voice into registers, made by physiologists, are sometimes based on theories in regard to the manner of their production; and if these theories are not correct, the division into registers must be faulty. Again, there are such marked differences between male and female voices, that it does not seem possible to apply the same divisions to both sexes. There is no difficulty,

however, in recognizing the qualities of voice called bass, barytone and tenor in the male, or contralto, mezzo and soprano in the female. A natural and proper division of the voice into registers should be one easily recognizable by singers and teachers of singing, and this must be different for male and female voices. If a division were made such as would be universally recognized by the ear, irrespective of theories, it would remain only to ascertain as nearly as possible the exact vocal mechanism of each register. It must be remembered that the voice of a perfect singer shows no recognizable break or line of division between the vocal registers, except when a difference is made in order to produce certain legitimate musical effects. One great end sought to be attained by vocal training in singing is to make the voice as nearly as possible uniform throughout the extent of its range; and this has been measurably accomplished in certain singers, although the number of such artists is not great.

Judging of different registers entirely by the effect produced upon the ear, both by cultivated and uncultivated singers, the following seem to be the natural divisions in the male voice:

I. The chest register. This is the register commonly used in speaking. Though usually called the chest voice, it has, of course, no connection with any special action of the chest, except, perhaps, with reverberation of air in the windpipe and the larger bronchial tubes. This register is sensibly the same in the male and in the female.

II. The head register. In cultivated male voices a quality is often produced—probably by diminished power of the voice, with some modification in the form and capacity of the resonant cavities—which is recognized as a "head voice" by those who do not regard the head voice as equivalent to the falsetto.

III. The falsetto register. By the use of this register the male may imitate the voice of the female. Its quality is different from that of the chest voice, and usually the transition from the chest to falsetto is abrupt and quite marked. It may be called an unnatural voice in the male; still, by very careful cultivation, the transition may be so skilfully made as to be almost imperceptible. The falsetto never has the power and vibrant quality of the full chest

voice. It resembles the head voice, but every good singer can recognize the fact that he employs a different mechanism in its production.

Applying an analogous method of analysis to the female voice, the natural registers seem to be the following:

I. The chest register. This register is the same in the female as in the male.

II. The lower medium register, generally called the medium. This is the register commonly used by the female in speaking.

III. The upper medium register. This is sometimes called the head register and is thought by some to be produced by precisely the same mechanism as the falsetto register in the male. It has, however, a vibrant quality, is full and powerful and is not an unnatural voice like the male falsetto.

IV. The true head register. This is the pure tone, without vibrant quality, which seems analogous to the male falsetto.

According to the division and definitions of the vocal registers just given, in the male voice there is but one register, extending from the lowest note of the bass to the falsetto, and this is the chest register. In the low notes the vocal chords vibrate, and the arytenoid cartilages, to which the vocal chords are attached posteriorly, participate in this vibration in a greater or less degree. In the low notes, also, the larynx is open; that is, the arytenoid cartilages do not touch each other. As the notes are raised in pitch, the arytenoid cartilages are approximated more and more closely, and they touch each other in the highest notes, the vocal chords vibrating alone. It is probable that the degree of approximation of the arytenoid cartilages is different in different singers, and that the part of the scale at which they actually touch is not invariable. This appears to be the case in laryngoscopic observations.

What has been called, in this classification, the head register of the male is not a full, round voice, but its notes are more or less sotto voce. This peculiar quality of voice does not seem to have been made the subject of laryngoscopic investigation. It has a vibrant character, which is undoubtedly modified by some peculiar action of the

resonant cavities. It is not probable that its mechanism differs essentially, as regards the action of the vocal chords, from that of the full chest register.

The falsetto register in the male involves such a division of the length of the vocal chords that only a portion is thrown into vibration. Concerning this there is no dispute. In the chest register either the vocal chords, with parts of the arytenoid cartilages, vibrate, as in the lower notes, or the vocal chords, without the cartilages, vibrate in their entire length, as in the higher notes. In the falsetto voice, however, it can be demonstrated, by means of the laryngoscope, that the vocal chords are shortened, sometimes by one-third or even more of their length. When the chords are observed with the laryngoscope during the production of a falsetto note, the edges of their posterior portion are seen closely applied to each other, and there is an elliptical opening in front bounded by the vibrating edges. Sometimes in the production of high falsetto notes, a short portion of the edges in front is closed, and there is an elliptical space—the vibrating portion—occupying the central part of the chords. This is the difference between the falsetto register and all other vocal registers. It is probably because a very powerful blast of air from the lungs would separate the closed edges of the vocal chords, that falsetto notes are not so strong as chest notes and have little vibrant quality.

The mechanism by which the vocal chords are approximated in portions of their length has not been satisfactorily explained, but there is no doubt as to the fact of such action. The extent of such shortening of the chords must vary in different persons, and in the same person, probably, in the production of falsetto notes of different pitch. According to Mrs. Seiler this shortening is due to the action of a muscular bundle upon little cartilages extending forward from the arytenoid cartilages in the substance of the vocal chords as far as the middle; but dissections by competent anatomists have failed to confirm this view.

Some singers, especially tenors, have been able to pass from the chest to the falsetto so skilfully that the transition is scarcely apparent; but the falsetto never has the vibrant quality of the chest voice.

The chest voice in the female does not differ from the chest voice of the male, either in its general quality or in the mechanism of its production. In the best methods of teaching singing, one important object is to smooth the transition from the chest to the lower medium. The full chest notes, especially in contraltos, closely resemble the corresponding notes of the tenor.

Laryngoscopic observations show that the mechanism of the lower medium and upper medium in females does not radically differ from the mechanism of the chest voice. In these registers the arytenoid cartilages are brought nearer and nearer to each other as the voice ascends in the scale, until, in the higher notes, they actually touch. It is probable that the vocal chords alone vibrate in the lower and upper medium, while parts of the arytenoid cartilages participate in the vibrations in the female chest voice. Still, in the lower and upper medium the vocal chords are not divided but vibrate in their entire length.

The vocal chords are much shorter in the female than in the male and the larynx is smaller. In the male the length of the chords is about seven-eighths of an inch, and in the female, about six-eighths of an inch. If the chords alone vibrate, without any part of the arytenoid cartilages, the difference in length would account for the differences in the pitch of the voice in the sexes. A tenor can not sing above the chest range of the female voice without passing into the falsetto, to produce which he must shorten his vocal chords so that they become as short or shorter than the vocal chords of the female. This is shown by the scale of range of the different voices compared with the length of the vocal chords; and this idea is sustained still further by a comparison of the male larynx, during falsetto production, with the female larynx. In the male falsetto, produced by artificial shortening of the vocal chords, the more nearly the resonating cavities are made to resemble, in form and capacity, the corresponding cavities in the female, the more closely will the quality of the female voice be imitated. It is probable that the vocal chords in the female present a thinner and narrower vibrating edge than the chords in the male, although there are no exact anatomical observations on this point. This may account for the peculiarly clear quality of the upper regis-

ters of the female voice as compared with the male voice or with the female chest register. Analogous differences exist in reed instruments, such as the clarinet and the bassoon. This comparison of the female upper registers with the male falsetto does not necessarily imply a similarity in the mechanism of their production, as is assumed by some writers. The vocal chords in the female lower and upper medium vibrate in their entire length; in the male falsetto, the chords are artificially shortened so that they are approximated in length to the length of the chords in the female.

To reduce to brief statements the views just expressed, based partly on laryngoscopic examinations—that are far from complete—by a number of competent observers, the following may be given as the mechanism of the vocal registers in the female, taking no account of the changes in form and capacity of the resonant cavities:

I. The chest voice is produced by "large and loose vibrations" (Garcia) of the entire length of the vocal chords, in which the ends of the arytenoid cartilages, to which the chords are attached posteriorly, participate to a greater or less extent, these cartilages not being in close contact with each other.

II. In passing to the lower medium, the arytenoid cartilages probably are not absolutely in contact with each other, but they do not vibrate, the vocal chords alone acting.

III. In passing to the upper medium, the arytenoid cartilages probably are firmly in contact with each other, and the vocal chords alone vibrate, but they vibrate in their entire length.

IV. The head register, which may be called the female falsetto, bears the same relation to the lower registers in both sexes. The notes are clear but deficient in vibrant quality. They are higher in the female than in the male because the vocal chords are shorter. Laryngoscopic observations demonstrating this fact in the female are as accurate and definite as those showing it in the male.

The reasons why the range of the different vocal registers is limited are the following: Within the limits of each register the tension of the vocal chords has an exact relation to the pitch of the sound produced. This tension is

limited by the limits of power of the muscles acting on the vocal chords for high notes, and by the limit of possible regular vibration of chords of a certain length for low notes. The higher the tension and the greater the rigidity of the chords, the greater is the force of air required to throw them into vibration; and this also has certain limits. It is never desirable to push any of the lower registers in female voices to their highest limits. All competent teachers of singing recognize this fact. The female chest register may be made to meet the upper medium, particularly in contraltos; but the singer then has practically two voices, a condition which is musically intolerable. In blending the different registers so as to make a perfectly uniform single voice, the vibrations of the arytenoid cartilages should be rendered progressively and evenly less and less prominent, until they imperceptibly cease when the lower medium is fully reached; the arytenoid cartilages should then be progressively and evenly approximated to each other until they are firmly in contact and the upper medium is fully reached. The female vocal apparatus is then a perfect organ. While single notes of the chest, lower medium and upper medium, contrasted with each other, have different qualities, the voice is even throughout its entire range; and the proper shading called for in musical compositions can be made in any part of the scale. The blending of the male chest register into the falsetto and of the upper medium into the female falsetto, or true head voice, is more difficult, but it is not impossible. Theoretically, this must be done by shortening the vocal chords gradually and progressively and not abruptly, unless an abrupt shortening is required in order to produce a legitimate effect of contrast.

Even in singing identical notes, there are distinctly recognizable differences in quality between the bass, barytone and tenor, and between the contralto, mezzo and soprano. As regards female voices, these may be compared to the differences in identical notes played on different strings of the violin. For male voices, they may be compared to the qualities of the different strings of the violoncello. Falsetto notes may be compared to harmonics produced on these instruments.

These ideas in regard to the mechanism of the different

vocal registers have resulted, first, from a study of these registers from an esthetic point of view; then, from an endeavor to find explanations of different qualities of sound, appreciated by the ear, in laryngoscopic and other scientific observations, and not by reasoning from scientific observations as to what effects on the ear should be produced by certain acts performed by the vocal organs. It is well to remember, in this connection, that the works of John Sebastian Bach, Beethoven and other old masters, were composed exactly in accordance with purely physical laws, long before these laws were ascertained and defined, as has lately been done, particularly by Helmholtz.

XLIX

WHAT SHALL THE PUBLIC SCHOOLS TEACH?

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To say that the great and perhaps the only object of teaching in public schools is to prepare boys to be useful citizens and girls to be good wives and mothers is to state a proposition so evidently true that it calls for no discussion or argument. It is, in point of fact, so generally appreciated by the people, that they are ready and willing to contribute freely by taxation to accomplish this end; and the universal desire of those who reflect upon the subject is that the public moneys devoted to public education shall be so expended as to render the greatest service to the greatest number. How this is to be accomplished is one of the important questions of the day.

Nearly all occupations in life are crowded in cities, and in the large cities most of all. Certain professions, especially medicine and law, are crowded in nearly all countries. This is an evil—if it is an evil—that the people can not remedy. The fault, perhaps, lies in easy access to the professions in comparatively new countries; and this will gradually be removed by the professional schools. In a large city the crowding of certain occupations that do not involve much if any manual labor seems inevitable. There is an indefinable force which attracts a certain number to a great city from smaller cities or from the rural districts; and only a few homeless boys and girls, exported to the country from motives of charity, leave the great centres of population. In the city we are in the presence of a population of youth which will remain and should be prepared to struggle here for existence. How they are to be educated so that in this inevitable struggle they shall contribute their full share toward general prosperity and happiness is a question of importance; and with com-

pulsory education its solution depends largely on what the public schools teach.

There are many points of view from which the subject of public education has been and is to be considered, and by no means the least important is one which relates to health and physical strength. It is seldom that a man, other things being equal, meets with marked success in any calling if he is constitutionally feeble. In the professions, with equal acquirements, intelligence and opportunities, it is the physically strong who succeed; and it is nearly always the strong who make their own opportunities. Whatever the public schools may or might teach, if the development and preservation of health and strength is lost sight of, the training is defective.

From a purely physical point of view, it may properly be inquired whether the hours of attendance and study and the attitude of scholars rendered necessary by the form of seats and desks in public schools are such as to interfere with normal physical development, and whether the development of the body may not be promoted by physical training as a part of school instruction.

The hours of attendance and study at public schools —attendance on two daily sessions, the first of three and the second of two hours—even with the study at home, are not too much, especially as the five hours of attendance at school do not represent five continuous hours of mental labor. In my judgment it is an error to suppose that school children are often overworked. Assuming an average health and strength, it is rare to observe any impairment of physical or mental vigor directly attributable to close study, at least in public schools, provided the children are well nourished and take proper exercise. This question of overwork is one which would inevitably be settled by those who prescribe courses of study for large numbers of pupils. It would very soon be apparent if the tasks were too severe for the average of children, and the remedy would be promptly applied. As regards the influence of study on the health of girls, the proposition that the public-school children are overworked was answered very decidedly in the negative by Miss Mary G. Tate, principal of a New York grammar school, in a recent discussion.

The ventilation in most of the public schools in New York and the form of desks and seats are fairly in accordance with hygienic laws. Serious injury would result from inattention to plain hygienic principles in this regard in growing children; and this is much more likely to occur in private than in public schools. In regard to questions of hygiene, therefore, it does not appear that the conditions under which children are placed during the hours of attendance at school are unfavorable to proper physical or mental development.

A more important question, and one which properly comes within the province of the physician and physiologist, relates to the advantage of physical training as a part of the discipline and education of school children. In many private schools, especially the so-called military schools for boys, physical training is very prominent. As a part of the education of young men, the advantage of careful and thorough physical training, involving even severe physical exercise, is well illustrated at the United States Military Academy at West Point. It is true that the students at the Academy are subjected to a careful physical examination and when admitted are practically perfect in their physique, having no recognizable vices of constitution; but the four years' course of mental and physical training is severe and exacting; and the hygienic conditions in regard to food, hours of sleep, absence of vicious habits, such as intemperance, excessive smoking, etc., leave nothing to be desired. Taking all these circumstances, however, into consideration, the result of four years' training, both physical and mental, is a class of men perfect in bodily health and vigor. Very few break down physically during the course, and fewer still are rejected on account of physical disability at its close. These statements are made after a pretty thorough examination of the methods of training at West Point, and they are in accordance with the views of army surgeons who have long been attached to the Academy.

The practical question of physical training in public schools is, however, one of considerable difficulty. There is no physical selection of pupils; the age is such that severe physical training would be injudicious, even if practicable; teachers have no control of pupils out of school

hours; the hygienic conditions at home are seldom of the best; and it is impossible to guard against bad habits, such as the prevalent vice of cigarette-smoking. These and other like considerations render impracticable any complete and thorough system of physical training in public schools; but on the other hand, it seems that much good may be accomplished in this direction.

Young children, when in perfect health, take a great deal of light physical exercise. Their simple games and sports, for girls as well as boys, are full of active movement. These should be encouraged and so far as practicable subjected to intelligent direction. The more that healthful amusement can be combined with physical training the better; and it requires much more time devoted to purely muscular exercise to develop a growing child than to keep the functions of an adult in a perfectly normal condition. Children consume, in proportion to the weight of the body, about twice as much oxygen as adults and exhale a corresponding quantity of carbonic acid, which are physiological measures of muscular activity. Children commonly do not accumulate fat to any great extent; and the carbohydrates of food and the fats are the chief matters oxidized, this process saving the elements of food which contribute to the development of the muscular system. Unless the muscles are properly exercised, especially in youth, their development is imperfect and irregular; and many begin the real struggle of life in early manhood under the disadvantage of a feeble physique, the result of faulty hygiene in childhood.

Assuming that the great object of early education at public expense is to make useful members of society in the different and inevitable social grades, will it contribute to that end to give any considerable part of the time to purely physical training? In other words, will it pay to devote more time in the schools to physical culture?

In communities that maintain large standing armies, upon which the public safety is supposed to depend, this question would undoubtedly be answered in the affirmative. In Germany, for example, physical education in childhood and youth is much more prominent than it is here. A large part of the life of the most useful members of society, so far as production is concerned, is taken

by the state for the ostensible purpose of protecting the state. Physical training goes hand in hand with mental discipline and the enforcement of obedience, punctuality and decorous conduct. Could not the qualities thus developed be made here indirectly useful to society in improving the physique and morals of rising generations? There is little room for doubt in regard to this, and it is a question, indeed, whether it is not more important to fit men and women physically for their life's work than simply to train the intelligence, leaving the body to take care of itself. In selected individuals subjected to the highest degree of mental as well as physical training, the experience of the Military Academy at West Point shows that the "candle is not burned at both ends." The same should be true in the majority of young persons trained less severely for usefulness in ordinary vocations. As a rule those who seek relief in public hospitals and those who are inmates of pauper institutions are burdens on the community by reason of excesses; and these excesses are largely the result of physical inability to cope with the world. The law of the survival of the fittest applies to man, educated or uneducated, as well as to the lower animals; and it seems useless to educate a man for work which he is physically unable to perform. In many or most of our chief cities, wisely or not, provision has been made for public education, from the rudiments of knowledge to the highest grades of mental culture. The number of those who, in passing to the higher grades, are able and willing to avail themselves of the educational advantages thus afforded is progressively smaller and smaller; but it seems wise to see to it that all shall be taught at least to read, write and cipher. With these simple acquirements, all should be compelled so to develop their physical organization that they shall have a healthy mind in a healthy body.

So far as I can ascertain, physical culture in public schools does not exist, except in the form of so-called callisthenic exercises for girls, which do not involve enough muscular exertion to be of any sensible benefit. There is no provision whatsoever for boys. If I am correct in my estimate of the importance of physical culture, the only questions to consider are those of expense and prac-

ticability. Aside from the question of expense, the provisions for proper physical culture are simply a suitable room and grounds, a single hour after the ordinary school exercises are completed and competent direction and instruction.

The hour may be taken from the ordinary course of instruction or an additional hour might well be given. The room and grounds—a room for inclement weather—and properly selected gymnastic apparatus are mere questions of expense; but the most important and difficult part of the problem is the selection of competent teachers. To organize a system of physical culture on a proper scale, there should be an efficient superintendent of this department for all the schools, under whose direction the apparatus should be constructed and kept in order. Competent instructors should be appointed, one for each school, and under his direction all pupils should be compelled to take proper exercise, at least three times in the week, for one hour after the close of the ordinary school session in the afternoon. A male instructor could very well conduct both the boys' and the girls' classes, and two hours in the week would be sufficient for girls. This definite suggestion is made after a not inconsiderable personal experience in gymnastics.

The subject of manual training in public schools is now engaging public attention and may well be considered in connection with what has been said in regard to physical culture. Early physical culture would serve as a natural preparation for manual training as well as a useful addition to the system.

It is recognized by nearly all writers on this subject that to teach a trade is not one of the legitimate objects of education in public schools. This is clearly set forth in a recent article on "Manual Training in School Education," by Sir Philip Magnus, who says that "the object of workshop practice, as a part of general education, is not to teach a boy a trade, but to develop his faculties and to give him manual skill." It is no more within the province of an elementary public school to teach the trades than to prepare boys for the professions, although an exception may be made in favor of schools for the training of teachers. With this reservation, there can

be no doubt in regard to the wisdom of establishing workshops in our public schools. This is not an untried experiment. In Great Britain, France, Austria, Belgium, Holland and Sweden the system has been thoroughly tried, and the results have been most satisfactory. If the experiment should fail in our public schools, the causes of failure should be looked for in defects either in the plan or in the efficiency of its execution. With plans already formulated and the experiment certain to be made at an early date, it would be out of place here to discuss details.

The most important use of the public schools, aside from the acquisition of a certain amount of knowledge, is in the general influence exerted on the mind and character of pupils. Personal cleanliness, habits of obedience and punctuality, honesty and a proper sense of personal honor are as important as knowledge acquired from books. A proper comprehension and use of the English language, with kindliness and courtesy of demeanor, contribute much to success in life. Brutality in school discipline belongs, happily, to the past; and civility and gentleness are not now regarded by any class as unmanly. A boy may be taught to be a true gentleman in his own sphere of life, however humble that sphere may be.

Leaving for others a discussion of questions relating to general education, an important subject relates to elementary scientific instruction. To what extent is it desirable to teach the elements of chemistry, physics and human physiology? It is beginning to dawn upon the minds of men interested in the higher education that actual knowledge has made great, not to say enormous progress within the last century; and that what an educated man must know at the present day is not to be measured by the standard of a liberal education of a hundred years ago. One can not now afford to spend much time in pure mental training by studies that do not convey a fair proportion of practical and useful information. The evils of a too close adherence to antiquated methods of education are shown in the distress of a large class of educated persons unemployed. To a great extent the very elaborate education obtained at some of our universities fits men only for elegant idleness; and the class of men of leisure in our own country is not large and does

not command much respect. Men and women who would be quite unwilling to be regarded as imperfectly educated frequently present a dense and impenetrable ignorance of all matters relating to science. In time this condition of things will undoubtedly be remedied, and perhaps the traditional elements of a liberal education will be unduly neglected; but now we should begin to emancipate ourselves from antiquated habits of thought and mental training. When it is remembered that Galileo lived only about three hundred years ago, that the discovery of the circulation of the blood was published in 1628 and that Lavoisier first applied accurate methods to the study of chemistry only in the latter part of the last century, it is evident that the sum of positive knowledge was comparatively small when the models of our present system of higher education came into existence. The best place to begin reform in education is at the beginning; and now that something positive and definite may be taught in regard to the sciences, it is well that these subjects should be taught as early as they can be properly understood.

The essentials of the philosophy of chemistry and the elements of physics are not difficult subjects. They are much easier of comprehension than the construction of the Latin and Greek languages, and they have the advantage, not alone of being matters of actual knowledge, but of indicating the methods by which scientific minds have arrived at truth. While a study of the ancient languages is useful and aids in the elegant expression of thought, a study of the sciences trains the mind to proper methods of thought. More of useful logic is learned from a study of experimental science and the reasoning from facts observed than from the so-called principles laid down in text-books; and scientific language, in its best form, expresses ideas in the fewest words and in the clearest construction.

The question of teaching anatomy and physiology in public schools is one which hardly admits of discussion, provided these subjects can be taught efficiently. This can be done by good teachers and with good books; but unfortunately good teachers of these subjects are few, and many of the text-books in common use are full of errors and faults. The errors of statement, however, are not so

serious as the faults in style. The amount of anatomy and physiology that it is desirable to teach, even to the higher classes in public schools, is not great; and it is an error to imagine that these subjects are necessarily encumbered with technical names and expressions. All the anatomy that is required is simply what is sufficient to enable pupils to comprehend physiology. The fault that I find with many schoolbooks is that the authors attempt to go too far. If pupils are taught the general mechanism of bones and joints, the actions of the most important sets of muscles, the general arrangement of the brain and nerves, the general characters of the blood and the mechanism of the circulation, the theory and mechanism of respiration, the characters of food, and certain simple facts in regard to the action of the digestive fluids, absorption and the general action of glands, with simple explanations of the senses of taste, smell, sight and hearing, they will know enough of anatomy and physiology for all practical purposes. Brief statements embodying the essential facts involved could be made in hardly more space than is occupied by this article; and a competent instructor, with the aid of a blackboard and colored chalks and with very moderate skill in drawing, could easily teach these subjects. According to my observation, however, anatomy and physiology are not taught efficiently in schools, partly for the reason that the text-books treat these subjects too elaborately and partly because there are no teachers specially trained for that kind of instruction. The simple laws of hygiene, of course, follow naturally upon physiology.

If anatomy and physiology are to be taught in public schools, and if the efficiency of instruction depends so largely on the instructors, who is to teach the teachers? It is difficult to answer this question. The courses on anatomy and physiology in medical colleges are not adapted to this purpose. Medical students are taught in what is practically a new language; and the most intelligent school-teacher, were he to attempt to learn in a medical college how to teach anatomy and physiology to his pupils, would be infinitely embarrassed in selecting his subjects and in eliminating what is unnecessary. It is a difficult thing to popularize science. Professional men

hardly know how little, and laymen how much it is desirable to teach. Popular physiology is not by any means a simple translation of technical terms into ordinary language; it is the clear and simple expression of facts in the science, that should be a part of the knowledge of educated persons, in terms that are readily comprehensible by the people. Every one knows that he moves, breathes, feels, sees, hears, tastes and smells, and that certain other important functions are carried on in the body. A knowledge of how these functions are performed should be a part of a fair education. An annual short course of lectures to teachers, in which not only the subjects should be taught but the best methods of teaching illustrated, would be most useful; and some such method of training teachers must be adopted before instruction in anatomy, physiology and hygiene, and the course to be pursued in ordinary emergencies, can take its proper place in the curriculum of public schools.

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THE AMERICAN MEDICAL STUDENT

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I do not intend to inflict upon those of my fellow alumni whom I have the honor to address this evening a dissertation on medical education. Different phases of this subject are periodically presented to the profession, from different points of view according to the character and the field of experience of those interested. It is not seldom the case that persons long unfamiliar with methods of medical instruction undertake to decide how medicine should be taught, judging only from a dimly remembered experience of a student life of many years ago. Others, unconsciously influenced by interest in some special method employed in a school with which they are connected, are disposed to regard every other plan as inefficient; and some, generally not connected with medical colleges, seem to be penetrated with a desire to decry the methods of teaching in our own country. Revolutions in science or in teaching are not made in a day. Thirty-one years ago I attended my last course of lectures at the Jefferson Medical College; and were I to contrast the opportunities afforded to medical students to-day with those which I enjoyed in 1856-'57, I could show what almost amounts to a revolution in methods and efficiency of teaching; but this has been the growth of more than a quarter of a century. An experience of thirty years as a medical teacher has convinced me that if the past can be taken as an earnest of the future, improvements in medical training may be safely left to the great medical colleges of this country. American physicians, medical authors and teachers need no eulogy, much less defense. Not so, per-

haps, the American medical student; although, as "the child is father of the man," the medical student is father of the physician.

What is the present status and general character of the American medical student? It is safe to say that this question can be answered by few physicians, even though they may have had long experience in medical teaching. Professors are not always brought closely in contact with individual members of their classes, especially in large schools. The professorial routine usually is to give lectures and examine candidates for graduation. The daily life of the medical student is something which most professors know little or nothing about; but one who knows this life finds much to commend and little to condemn in the average student.

As a general rule students desire to learn medicine. They enter upon the study voluntarily and with a will. They realize that the information which they hope to acquire at a medical college is not simply ornamental, but is to be the basis of their future material prosperity and happiness, the foundation on which they are to build character and reputation, and the starting point of their career as men. It frequently happens that one who has been careless and neglectful before beginning the study of medicine becomes an earnest and devoted medical student. All good students are interested in their work and are quick to appreciate the importance and practical bearing of what they are taught. All students, good, bad and indifferent, have an acute appreciation of the disgrace attending a failure to pass their final examinations; and this sentiment largely reduces the number of those who actually fail. No one, as a rule, knows better than does the candidate himself, the extent of his knowledge of medicine; and students measure the acquirements of each other with singular accuracy. Those who fail in their final examinations are expected by their fellow students to fail; and in competitive examinations, students seldom make errors in estimating the rank which will be assigned to candidates.

One who is familiar with the American medical student naturally divides the class into varieties. The following classification seems to me to be sufficiently dis-

tinct: 1. The good student; 2. The average student; 3. The poor student. This classification I have made from the records of the college with which I am connected, on the following basis:

1. Good students, receiving 80 or more per cent. of marks out of the highest possible in their final examinations = 25 per cent. of the total graduated.

2. Average students, receiving between 70 and 80 per cent. = 45 per cent. of the total graduated.

3. Poor students, receiving less than 70 per cent. = 30 per cent. of the total graduated.

The twenty-five per cent. of the candidates for graduation, ranked as "good students," exercise a great influence over the general opinion of the class. These students practically keep themselves apart from the others, and they have nothing in common with those classified as "poor students." Their habits are almost invariably good; they are present at all the prescribed exercises; they dissect together, usually collect in the same boarding houses, and form little clubs among themselves for "quizzing," and mutual improvement. When one of this little coterie is forced to miss a day's attendance, his fellow students aid him in filling the gap. Their amusements during the session are few, and the work they do is enormous. Their verdict upon the ability and efficiency of individual teachers is accepted by the class as final. They usually take under their protection certain of their juniors, who assume their position in the class when they have been graduated. The "good students" pass their collegiate life in an atmosphere of medicine. Medicine is the only subject which occupies their thoughts and conversation. Generosity of students of this class toward each other is almost invariable. In competitive examinations for hospital appointments, I have never known of any expressed dissatisfaction with results, nor have I seen evidences of envy, on the part of the unsuccessful, of their more fortunate fellow candidates.

I have been curious to ascertain certain facts in the personal history of "good students." Out of the number of this class graduated at the college with which I am connected, in 1886, one-fourth were from the State of New York; the others were residents of States north,

south, east and west, seventeen States being represented, including Canada and Nova Scotia. I do not find a proportion of men who had received a collegiate education much larger than in the general class of graduates, although those who had been graduated in Arts usually were superior to those of less thorough preliminary education.

On the whole the "good students" graduated at our large medical colleges are a credit to their class, and, I believe, will compare favorably with recent graduates in any country and under any system of teaching. In my observation, the number of such graduates is increasing, and the professional "esprit" in this class is becoming more and more marked. The standard of acquirement attained by our best graduates of the present day well merits the admiration of those who are able to compare it with the highest standard of thirty years ago.

The "average student" here is about the same as the average medical student elsewhere. He does not attain the rank of the "good student," for many and various reasons. Many average students are sadly deficient in mental training, even if their preliminary education is up to the proper standard. Many students do not know how to study. Many are careless and have no fixed purpose, no enthusiasm, no capacity for consecutive mental effort. Some are bright, quick and apt, but indolent. They may be "crammed" for their examinations, and thus escape from the class of "poor students," but their knowledge is superficial and indefinite.

The "poor student" is a poor creature indeed. Those who are but little above the unfortunate candidates who fail in their examinations seldom do any credit to themselves or to the profession, although there are some rare exceptions.

American medical students as a class are different from medical students in other countries. This is due in part to a great difference in our method of teaching. In this country nearly all the teaching which students receive is given by the faculties of our medical colleges and the official corps of teachers. Students are brought in close contact with each other and assemble daily in the lecture-rooms. Few students, during the sessions of the colleges,

have any social life beyond their associations with their fellow students. "Cramming" by special instructors not connected with the colleges is much less in vogue than formerly, at least in New York, and there is now comparatively little "cutting" of lectures and trusting to hard work for a short time to make up. Meeting with each other daily, students quickly form friendships with those who are congenial. The days are so fully occupied, as well as the evenings, that students usually are not fastidious about their lodgings or dress, and many make great sacrifices in order to be able to attend what is thought to be a first-class college. They are more ready to assist each other, pecuniarily and otherwise, than any class of men with whom I have been brought in contact. I have often known students to lend their last dollar to a fellow student in trouble. Strange to say, the temptations of a large city have little influence on medical students as a class; and as a rule they are sober and temperate. In an experience of thirty years of close contact with medical students, I have met with but few instances in which they have become disgracefully involved in affairs with the opposite sex.

As a rule students have a genuine affection for the college of their choice; and especially in cities in which there are rival institutions, they are earnest partisans. The "assisted" student (one who does not pay his full college fees) is an object of more or less pity and contempt. It offends a student's sense of justice to feel that a fellow student receives concessions in fees when others are perhaps making considerable sacrifices to meet the requirements of the college. Students have a nice sense of justice; and if all are treated alike and with absolute fairness, it requires but little tact to keep a large class in order.

Sectional feeling and prejudice, which were rife in the large schools thirty years ago, are fast disappearing. Personal quarrels between students are now very unusual. Boyish pranks in the lecture room are not uncommon, but it is seldom that a teacher is treated with disrespect.

Medical classes are merciless critics. Every professor and teacher is freely and fully discussed, and the opinion of those whom I have classed as "good students" be-

comes the nearly universal judgment. This judgment is handed down from one class to another; and a teacher who has made a positive failure in his first course of lectures has a difficult, almost impossible task before him in attempting to secure the confidence of his class. Ornate language and oratory, so called, are to be numbered among the lost arts of successful medical teachers. It is now almost universally recognized, by teachers and students alike, that the science of medicine has become too large to allow much attention to be devoted to what was formerly called elegant lecturing. As a rule the most popular teacher is the one whose teaching is most direct, simple and emphatic.

Many public-spirited medical men of the present day, not practically familiar with modern methods of teaching in medical colleges, have fallen into the error of assuming that the average medical education acquired in America is vastly inferior to what is usually attained in England, France or Germany. This is an error, at least as regards teaching in the larger American colleges; but the methods by which American students obtain their education is quite different from what obtains in European capitals. In this country the competition between the different colleges is most active, and, it is fair to say, this competition relates mainly to efficiency in teaching. There is little purely perfunctory performance of professorial duties. There are many justly eminent men in our profession here who can not succeed as teachers, for the art of imparting instruction is not to be acquired by every one. The fact that most of our successful colleges are self sustaining has a certain advantage. Each college aims to recruit its faculty with the best teachers; and as a rule each professor uses his best efforts to make the teaching in his department efficient. No amount of endowment or redundancy of apparatus and appliances for teaching can supply the place of vigorous and efficient instruction on the part of the teaching faculty of a medical college. Making some allowance for courtesy of expression on the part of foreign medical teachers who visit our schools, it is not too much to say that professors from abroad are surprised at the size of our medical classes in attendance on lectures, at the interest and industry shown by

American medical students and the vigorous style of teaching displayed in lectures. In America teaching by lectures has reached its highest development; and our system, supplemented by recitations and practical exercises, keeps our students constantly at work for the three years and produces results within that time fully equal, as regards the great majority of students, to those obtained by four or five years' study under the systems in vogue in Europe.

It is far from my intention to attempt to glorify American medical teaching. I speak only of the system carried out by the schools in our larger cities, with an abundance of practical and clinical material efficiently used. There are many medical colleges in this country that have no logical reason for existence, and in which the teaching is of a low order. The majority of our students recognize the defects of these schools and attend them only as a matter of necessity or from force of circumstances. It is not at this moment apparent how the existence of inferior medical colleges can be avoided.

Medical students in European capitals have, particularly at the beginning of their studies, certain decided advantages over American students. Abroad, a suitable preliminary education is the rule; and the requirements as regards certain elementary and collateral studies are much higher than ours. In the so-called practical subjects, however, I believe that American students have an advantage. Our system of instruction is eminently practical, and the study of what may be termed the theory of medicine by consecutive and connected didactic lectures being carried on in close connection with clinical teaching, our best graduates, as a rule, are singularly well prepared for the practical duties of their profession.

There is less opportunity here than abroad for students who have wasted the greatest part of their time to be "crammed" for their final examinations. This system of "cramming" is one of the greatest evils connected with examinations. In the city of New York, when candidates for hospital appointments were subjected to a competitive examination by a committee, the personnel of which was seldom changed, it was almost impossible for candidates to obtain appointments unless they had been specially pre-

pared for the examination by certain persons. These persons, by studying the questions asked at the examinations for a series of years, finally knew nearly every question that would be asked, with the answers that were expected. The result was that many of those who passed brilliant examinations were found, in the performance of their duties in the hospital, woefully ignorant and inefficient.

That the condition and opportunities of American medical students can be improved, there can be little doubt; and a question of great importance to the future of our profession is: What are the best practical means of securing the desired improvement?

Preliminary Education.—Before beginning the study of medicine, a student should have received a good English education, including a fair knowledge of mathematics, and should know something of the Latin language. To exact in addition a knowledge of a modern foreign language, would be to assume that English medical literature does not meet the needs of English-speaking medical students, which is certainly untrue. Still, a knowledge of French and German is a great advantage.

It seems to me that the desirability of a proper preliminary education is too evident to admit of discussion; but questions that properly and profitably may be considered are, whether a good English education and a fair knowledge of Latin are indispensable as preliminaries to the study of medicine, and whether the conditions which obtain in this country render it possible to exact these requirements of all students.

It is a fact, not only that some unpromising students, sadly deficient in early advantages and education, do well in their medical studies, but that a few have attained professional distinction. Such instances, however, are infrequent and occur only in those who begin the study of medicine young. As a rule a man of twenty-five, ignorant, uncultivated and without habits of serious thought and study can never learn enough medicine to pass his final examinations. In former years, when some colleges accepted "five years of practice as equivalent to a course of lectures," some of these "practitioners," after hard and honest work during an entire session, have developed, on their final examinations, a depth of ignorance truly mar-

velous. Those who attain success in the face of serious deficiency in early mental training are exceptions; and to them the labor involved in acquiring a professional education is enormous. A student with absolutely no knowledge of Latin may acquire the nomenclature of medicine without serious difficulty, as a child learns the words in a foreign language, but he is at a considerable disadvantage.

On the whole I think it may be fairly said that while proper mental training and a "liberal" education are very desirable as preparations to the study of medicine, there are certain men lacking these advantages, but having youth, ability, enthusiasm and industry, who can not be repressed. These, however, are the exceptional men, who seem destined to succeed under any and all circumstances.

In this country the only grade of medical men, as regards their pretensions to the position of practitioners of medicine, is determined by the degree of M.D. Licentiates without a degree form a very small proportion of the class of general practitioners. The professional income and social position of many physicians, even when actually overburdened with practice, are rewards so small as to exclude, to a certain extent, a very high order of talent and acquirements. A low grade of practitioners, however, must exist both in rural districts and in large cities, although the income of many is less than the average earnings of good mechanics.

It is difficult to suggest a practicable way in which those who receive the degree of M.D. from our colleges may be divided into classes; and it is to be feared that whatever division is made must continue for many years to depend upon the public. The only feasible method of making any distinction between graduates would be for certain colleges to issue special diplomas to those who have passed a preliminary examination and have studied for the full three years at such colleges. In other countries, under a more or less paternal form of government and where the practice of medicine is strictly regulated by law, the necessity of at least two grades of physicians has long been practically recognized. The relative position of the "officiers de santé" in France, and of the

apothecaries and general practitioners in Great Britain, is an illustration of this.

There is much that can be done by the faculties of medical colleges to improve the opportunities of medical students, to render teaching more efficient and to make it easier for students to acquire a knowledge of medicine. That efforts in these directions have been made with considerable success is sufficiently evident; but that more can be done, and easily done, is unquestionable.

Perhaps the most important change to make in college requirements would be the abolition of the private preceptor. Most students learn so little from their preceptors, so called, that the certificates of three years' study, as a general rule, actually represent nothing. A busy practitioner has no time to devote to his students and rarely gives them any systematic instruction. In the great majority of instances the country practitioner who takes students into his "office" exacts of them little services not always of a professional kind, puts into their hands old editions of medical works and tells them to read, this being the beginning and the end of the functions of the "preceptor." Certainly there are exceptions to the rule in regard to private preceptors; but what is desirable is to remedy defects which exist in the great majority of instances. If the term of study of medicine is fixed at three years, the instruction which students receive during these three years should be thorough, systematic and continued, with reasonable vacations, throughout the year. Such instruction is now provided at well-organized medical colleges and it should be made obligatory.

The following statistics point to the importance of this reform:

Of one hundred candidates for graduation, sixty studied with private preceptors, and forty spent one or more full years, including recitation terms, at medical colleges. The average of the marks of the former on final examination was $68\frac{4}{7}$ per cent., the highest being $88\frac{4}{7}$, and the lowest $52\frac{6}{7}$ per cent. The average of the latter was $78\frac{4}{7}$ per cent., the highest being $97\frac{1}{7}$, and the lowest $57\frac{2}{7}$ per cent.

The shortcomings and errors of judgment in teachers frequently present serious obstacles to the acquisition by students of the knowledge to be reasonably expected of

them after three years of study. Who is there among us who has taught for a number of years who can not now recognize great defects in his earlier efforts! These defects, however, have generally been incident to lack of experience and to efforts to accomplish too much in a single course of lectures. Having had a not inconsiderable experience in medical teaching, with an extensive and varied field of observation, I may, perhaps, be pardoned if I venture to give my own ideas of how American medical students should be taught.

Instruction by lectures is an ideal form of teaching. It is emphatic, it makes learning easy for students and removes many difficulties usually experienced by those who attempt to learn exclusively from books; provided, always, that the lecturer is a competent and conscientious teacher. Lecturers are popular in proportion as they impart instruction positively and clearly. Subjects of lectures are attractive to students in proportion as they seem to be practical and useful and are easily learned.

Many young lecturers, with industry, enthusiasm and an aptitude for teaching, greatly impair the efficiency of their instruction by endeavoring to cover the entire ground embraced in the subject assigned to them. Many older and experienced teachers err in giving to parts of their subject in which they are especially interested, undue time and prominence. Many fail to teach their subject thoroughly from lack of system and proper arrangement.

An ideal teacher in any department of medicine is one who knows his subject thoroughly; who appreciates those parts of his subject that present peculiar difficulties to students; who is systematic and consecutive, and so clear in his statements as to be never misunderstood; who has no undue pride of opinion and makes no attempt at personal display; who teaches emphatically and thoroughly what is essential, treading lightly and judiciously upon disputed questions; who remembers the processes by which he has learned his subject and the difficulties which he has himself surmounted; who keeps constantly in mind the possibility that the shortcomings of his class may be in a measure due to defects in his teaching. A good teacher is never dull. A dull and uninteresting lecturer is never a good teacher.

A public teacher should never relax his efforts to improve his methods. He should himself examine his class upon the subjects of his lectures, the most important advantage of this being in the fact that these examinations often reveal to him defects in his teaching. An ideal medical teacher is rare indeed. " La critique est aisée et l'art est difficile." Still, there may be those whose reminiscences of our Alma Mater date back as far as mine; and can we not vividly recall more than one grand figure in the history of American medicine, filling the ideal of what a public teacher should be!

In two courses of lectures, with two courses of systematic instruction by books and recitations, it is not difficult for a student to learn his chemistry, anatomy, physiology and materia medica, and to acquire the necessary technique of medical chemistry, microscopy and dissections. Anatomy and physiology constitute the groundwork of medicine; and the materia medica furnishes a considerable part of the means used in the treatment of diseases. It is most important that these subjects be taught so thoroughly and efficiently that students shall know them as they know a familiar language. This can best be done by lectures, with frequent repetitions and reviews, reinforced by recitations from books. The serious work of the first two years of study does not seem to involve much more than the acquisition of certain established facts taught dogmatically and impressed on the memory by repetition and thorough drilling. A student learns and forgets his anatomy, for example, once or twice before he becomes even a fair anatomist. It is evident enough that youth is the time for this. Anatomy and physiology give the grammar and a great part of the vocabulary of medicine; for the classification and nomenclature of diseases have, or should have, essentially an anatomical basis. I venture to assert that a well-educated boy of nineteen can learn anatomy, physiology and materia medica more easily and thoroughly in two years than can a ripe scholar of thirty in three. Learning by efforts of memory is not unattractive to the young, while it is often mere drudgery to those of more maturity of mind.

In my opinion students, while learning the so-called elementary subjects, should listen to lectures on the prac-

tical branches and should attend clinics. It should be borne constantly in mind by teachers that the final object of the course of instruction of medical students is to qualify them for the practice of medicine. Medical students should begin early to observe the aspect and treatment of disease and to witness surgical operations. They can not be too familiar with the practical duties of their profession. The notion that young students can not comprehend lectures on practice, surgery and obstetrics is not well founded. While students are devoting their best efforts to the study of the elementary subjects, it is useful to them to hear lectures on medicine and thus to learn from the first the practical value and importance of a thorough knowledge of anatomy, physiology and materia medica. I make this statement after much reflection, observation and inquiry among intelligent students at different periods in the course of study.

After a student has devoted two years faithfully to the elementary subjects, if found qualified on examination, he may safely leave these branches and devote the remainder of his term of study exclusively to the practical departments. While he is studying practice of medicine, surgery and obstetrics, it is not possible for him to forget his materia medica, physiology and anatomy. His memory is being constantly refreshed by the applications of the primary branches to the study of actual disease. Now is the time to gather up what he has seen and heard on practical subjects in lectures and clinics during his first two years of study; and now he can become practically familiar with the methods and technique of physical diagnosis, surgical dressings, operations, etc.

Can a faithful student become qualified to begin the practice of his profession within a period of study extending over three years? Undoubtedly he can; but he must certainly not confine himself for one only, of these three years, to the study of the so-called practical subjects. He should be required to attend lectures and clinics on these subjects for at least two years. It seems to me absurd to exclude even a first-course student from everything that relates to the actual practice of our profession. I venture to assert that a first-course student can not occupy two or three hours of his day better than by attending

clinics and listening to lectures on practice of medicine, surgery and obstetrics, and that a student, pursuing such a course, will in the end be better qualified as a practitioner than if he had ignored these subjects during his first year of study.

No amount of what is called instruction can fully qualify a man to practice medicine. The conscientious study of a single case, of which he has the sole care and responsibility, is often of more practical value than the observation of a score of similar cases in a clinic. A recent graduate should be qualified to begin practice; but no preparatory training can equal the lessons of actual experience.

Neither the professor nor the student should expect to accomplish too much during the collegiate course. A mature practitioner who is an accomplished physician, skilled in all methods of diagnosis, a competent surgeon, an expert oculist, aurist, gynecologist, laryngologist, dermatologist, chemist, microscopist, bacteriologist, etc., is unknown. No length or amount of study can produce a physician of such varied accomplishment and learning, and the schools should not attempt impossibilities. A well-educated physician should have some knowledge of all departments of medicine and should be equal to any emergency; but the science of medicine has become too large for the grasp of any single intellect and the technique too multifarious for any one hand. It is an error to attempt to teach, thoroughly and exhaustively, even the legitimate specialties, such as ophthalmology and otology, in the ordinary curriculum of a medical college. Nevertheless, students should receive such an amount of instruction in the so-called special subjects as will enable them to recognize the diseases of all organs of the body and make no blunders in diagnosis and treatment. A legitimate specialty involves special dexterity, acquired by long practice as well as special study. A specialist who has an imperfect knowledge of general medicine is a dangerous practitioner. After graduation a student may study any restricted subject exhaustively; but his special acquirements and skill should always have as a foundation a comprehensive knowledge of the science of medicine. Without this no one can be a good practitioner, either as a surgeon or as a specialist of any kind.

There is one serious defect in medical teaching in this country which has been due to the rapid extension of the boundaries of medical science within the last quarter of a century. Actual knowledge at the present time is so extensive that lectures are necessarily confined to existing facts and opinions. It is not possible for each professor to enter to any considerable extent into the early history of his subject. It seems to me that a chair devoted to the history of medicine is now a desideratum. Students are now graduated with little or no knowledge of the history of the great discoveries and advances in medical science; and this defect could be met without materially increasing the labors of a medical class. It is also desirable that students should have some idea of the proper ethics of intercourse with fellow practitioners. There are points of strictly professional etiquette that are as important to the medical practitioner as are the polite usages recognized by gentlemen; and it certainly is proper and desirable that medical students should be told something of the proprieties and amenities of professional life.

I fear I have wandered from the direct question of what can be done to improve the condition of the American medical student. When I say, what can be done, I mean what is practicable in the near future, securing the greatest benefit to the greatest number. It may be well, however, to begin by considering what can not be done.

It is impracticable to bring all the medical schools of the different States under the control or supervision of the general Government. Our political organization does not admit of this, which can exist only under a centralized power, and would involve a considerable expenditure of public moneys. In my opinion absolutely uniform medical legislation in all the States is equally impracticable.

State medical boards, appointed to determine by actual examination the qualifications of applicants for license to practise medicine, are greatly crippled in usefulness so long as it is deemed necessary to recognize in their organization, certain so-called systems of practice, such as homœopathy and eclecticism.

State medical boards, appointed to determine the value

of different medical diplomas, must be inefficient and frequently absurd in their operations, so long as schools which we call irregular are recognized and the status of medical colleges is determined simply by college circulars and announcements. The profession knows that there is but one science and art of medicine, sufficiently broad, liberal and comprehensive to embrace all that is useful in the healing art, and that professional sectarianism is illogical, artificial and insincere.

No general medical examining board can be entirely efficient and useful unless the majority of its members are medical teachers, qualified by constant study and experience to test the acquirements of candidates in the science of medicine as it exists to-day, not as it was a decade or more ago.

As regards the medical student himself, it is not possible to secure for him efficient and thorough instruction by legislative enactment or even the liberal endowment of medical colleges. His condition is likely to be improved by honorable and generous rivalry and emulation among colleges in regard to the practical efficiency of their teaching. Improvements in medical teaching, judging from the past, probably will originate in the colleges themselves. No medical college in this country can afford to stand still; and I venture to assert that no step in advance in medical education has been hastened by resolutions of medical societies or by legislative action.

I should like to see a permanent association of the most prominent medical colleges of this country organized for the purpose of securing certain reforms and improvements in medical teaching and in requirements from students. These reforms and improvements seem to me to be the following:

I. A uniform standard of requirements for matriculation, to be determined by an association of colleges, and the subjects for examination to be definitely stated so that students may be able to prepare themselves properly before applying for matriculation. In my opinion this reform is a question of a few years only.

II. Students should be required to spend at least three full years in study at recognized medical colleges, and certificates of study from so-called private preceptors

should not be received. This, also, is simply a question of time. Many colleges now have recitation terms, attendance upon which is optional. It will not be long before it will be generally admitted that medicine can be taught properly only by professional teachers.

III. Students should be required to attend at least three regular courses of lectures, embracing at least two full courses on each subject, with final examinations at the end of the second and third years. This is a reform which is gradually but surely making its way. The knowledge required of students before they can be graduated has become so extended that it is more and more difficult for them to prepare themselves properly for examination in the course of two regular college sessions. It is an error to assume that students wish to obtain their degrees on the easiest possible conditions. The great majority of students desire to qualify themselves thoroughly for the practice of their profession. The statistics of the only college to the records of which I have access are very instructive on this point. In this college, the attendance on more than two courses is optional, and its classes are made up of students from all parts of the United States, with some from foreign countries.

In 1867 24 per cent. of undergraduates who received the degree of M.D. voluntarily attended more than two courses of lectures. In 1877 the proportion was increased to 36 per cent. In 1887 this proportion was increased to 62 per cent.

IV. In the interest of the profession and especially of those who are about to enter the profession, something should be done to remedy the evil of the existence of medical schools in which it is impossible for students to obtain a thorough medical education. In 1886 the total number of "regular" medical colleges in the United States was 90. In 1885 these colleges graduated 3,094 students. Out of the total of 90 colleges, 12 graduated 1,369, nearly one-half of the total of graduates for the year. It is useless to look to legislatures or medical boards or societies for any remedy against medical colleges, ostensibly regular, publishing circulars setting forth admirable plans of teaching, etc., etc., but whose existence is a scandal to the profession and a fraud on the American

medical student. Whatever relief is possible must come from medical colleges of established reputation, which should combine in declining to recognize the courses of lectures and the degrees of certain colleges that have no claim to the confidence of the profession. The confidence of the profession in the various medical colleges is measurably indicated by the actual support which the different colleges receive. A college can not be said to receive the support of the profession if the number of students availing themselves of its educational advantages and seeking its degree is ridiculously small. This, moreover, is the case in regard to a large number of colleges in this country; and the sooner such colleges cease to exist the better. In studying the college statistics for the year 1885–'86, I have found thirty colleges each graduating not more than twelve students. The average number of graduates of these thirty colleges was 7.7. Two colleges graduated twelve students each, the highest number, and one college graduated but one. The last-mentioned college has seven professors, one demonstrator and one lecturer. For the convenience of students occupied in other pursuits during the day, all the lectures are given in the evening. The college requires a matriculating examination and has a "graded course" of three years. It is the medical department of a university, and in addition to the clinical and other advantages enjoyed by its students, "the diplomas from this school are signed by the President of the United States."

It was not my intention, when I selected the subject of this address, to do more than sketch the personal characteristics of the American medical student and to try to show why he is what he is; but my interest in medical education has led me into topics that I did not at first propose to discuss. With all that may be said of medical schools that certainly do us no credit, their influence is relatively so small that they are practically of little importance in comparison with the great institutions of learning which have made the profession of this country what it is to-day. We can certainly be pardoned if, at this reunion, we point with pride to the commanding and honorable position which the "Jefferson" has maintained for more than threescore years. Steadily she has ad-

vanced in usefulness and influence. May her progress in the future equal the record of the past! Let us, one and all, whatever our other interests may be, cherish the "Jefferson" and encourage her in her good work! The honor and dignity of the profession rest largely with our great medical schools. The American medical student is confided to their care, and the schools will not betray the trust. Medical students are always benefited by honorable competition and emulation between colleges. We can do much to encourage this generous rivalry by striving to promote cordial feeling and concert of action in important matters relating to medical education. We who are connected with colleges should not be envious of the honorable success and prosperity of our rivals, nor should we be unwilling to follow if we do not always lead. We can not keep pace with the rapid progress of medical science without effort. Let us hope that our Alma Mater may never relax her efforts in behalf of American Medicine.

LI

JUST THE BOY THAT'S WANTED FOR THE MEDICAL PROFESSION

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I THINK I know just the boy that's wanted for the medical profession, although I must confess that such a boy is not often found. Perhaps some such boy may read this and recognize the fact that he had better study medicine. If that should happen I shall do good to one boy at least; for a boy who will make a good physician or surgeon will do much better in medicine than in any other profession or calling. But there should be no mistake about this. If a boy is not adapted to the medical profession and if he should be so unfortunate as to adopt this profession, he will be neither successful nor happy in his life's work.

I think I may assume that the summit of human happiness is to be found in doing congenial work with health, strength and the results of success and with a capacity for their enjoyment. To some boys and some men, work is always irksome; but such men are seldom happy and they count for but little in the world. Some boys find the work of obtaining a suitable education wearisome until they begin something to which they are peculiarly adapted and see that this kind of work is to be the basis of their success in life.

When I shall have given an idea of what the study and practice of medicine is I shall be better able to describe just the boy that's wanted for the medical profession. Medicine has little or nothing in it that is not attractive to one who has a taste for study. Every medical man who is interested in his profession looks back upon his student days as the happiest of his life. Every branch

of the study bears so directly upon the one great end, which is the relief of human suffering and the preservation of health, that nothing in it is irksome to an earnest student. Mental training and useful knowledge go together. A boy feels that he is beginning to be a man when he is learning to do the work of a man. He begins first to learn a new language, and this is absolutely necessary. The technical terms, which seem at first strange and useless, really save words; for single words often express ideas and facts that would require many sentences in ordinary language.

Everything that is learned in the study of medicine is useful. Chemistry is put in practice every day. Anatomy is the groundwork of physiology, practice of medicine and surgery, and is the basis of medical language; and a knowledge of remedies furnishes the weapons for daily use in contending with disease. There are no sentimental drawbacks in the actual study of medicine. The medical student has yet to meet with the ingratitude, jealousy and disappointments which fall more or less to the lot of every physician.

As a man he begins to apply what he has learned as a boy. His Latin and Greek give him a key to the definitions of medical terms. His mathematics and natural philosophy help him in anatomy and physiology. His geography aids in studying the effects of climate. His rhetoric enables him to put what he has learned in proper language. In studying medicine, what is learned is actual knowledge and not the mere traditions of books.

"The proper study of mankind is man." Such is the study of medicine.

So much for the study; now for the practice!

It is sometimes said that the practice of medicine is as full of disagreeable incidents and hardships, as the study is of genuine satisfaction and intellectual enjoyment. This may be true of medicine as a trade, but certainly not as a profession. It is not easy to attain success in any calling; but success is not more difficult in medicine than in other professions. If a physician is always a student he will enjoy the practice of medicine. He may reasonably expect to be able to earn a fair living; and if there is any satisfaction in doing good, he has chances enough to ex-

ert himself in that direction. An honest and devoted physician makes warm friends and is always respected. It would take too long to present even a sketch of a doctor's life; but its dark side is no darker than the dark side of life in some other occupations, while its bright side shows more rational and enduring happiness. One thing, however, is indispensable. A physician must love his profession and be well adapted, in mind and body, to its study and practice. This is why it is well for a boy to know it, if he should happen to be just the boy that's wanted for the medical profession. Such a boy can do much to prepare himself for the study of medicine, if he only knows how to go to work.

As a general proposition a boy to do well in the study of medicine should be neither rich nor poor. A boy who has an idea that it will not be necessary for him to make his own way in life will seldom do the hard and constant work required of a good student. A poor boy who is not able to get the best instruction is at a great disadvantage. A good constitution, good health and good habits are essential. Without a vigorous constitution an ambitious student is likely to break down. These qualities are necessary in every calling, but especially in medicine. A man of loose morals and bad habits is not fit to be trusted with the lives and innermost secrets of the sick and afflicted. If a boy has these general qualities, what is there to show that he is adapted to the medical profession? I have watched the course of many medical students, some of them very young. Some boys at school are not content with merely learning their lessons so as to make good recitations, but they wish to know the reasons why. They wish to know how discoveries have been made, how the facts which they are taught were originally learned; they hope they may discover something themselves, and they wish to know how it is done. A boy with such a turn of mind will do well in science. In almost all common schools an attempt is made to teach a little anatomy, physiology and hygiene. When a boy with scientific tastes gets a glimpse of these studies, he soon knows whether or not he will like the study of medicine.

Some boys learn by memory alone, like a child or a parrot. This kind of boy and this kind of study will not

succeed in medicine. In an old satire, called the "Physiology of the London Medical Student," is a humorous illustration of this kind of study applied to medicine. I hardly think that much medicine is to be learned from such things as the "Students' Alphabet," which begins:

> "Oh, A was an Artery, filled with injection;
> And B was a Brick, never caught at dissection.
> C were some Chemicals—lithium and borax;
> And D was a Diaphragm, flooring the thorax."

I have seen students who have learned by rote, who passed good examinations, but who knew absolutely nothing when put in charge of a case in the hospital. The traditions of medical colleges are full of anecdotes about students who try to learn in this way. One of these is the story of the student who was asked the situation and number of the viscera. He promptly answered that "the viscera are contained in the abdomen. They are a, e, i, o, u, sometimes w and y." A contrast to this is the story of the student who supplied his want of scientific knowledge by ready wit and common sense. His professor asked him, if he were called to a man who was insensible, how he would make a diagnosis between apoplexy and drunkenness? He answered, "By smelling his breath"; which, in fact, is the best possible test, unless the man should happen to have a stroke of apoplexy while intoxicated.

I wish to advise a boy what, in my judgment, he should do to prepare himself to study medicine.

The first thing to do is to make sure of a good English education. He should learn how to speak and write the English language correctly. A physician is expected to have a great deal of general information and he should not be ignorant of geography, history and general literature; but above all, he should be able to write clearly and express his ideas in few words. Too many neglect the study of the use of words; and a knowledge of rhetoric is most important. It is also a great advantage to a physician to be able to speak well in public, when he has anything to say.

It is important to have a fair knowledge of Latin and Greek, not only in order to be able to understand the construction of our own language, but to appreciate the

meaning of medical terms. A knowledge of French and German is useful, much more useful than the higher studies in Latin and Greek, but it is not indispensable.

A boy should study mathematics thoroughly. Some branches of medical study can not be learned without a previous knowledge of mathematics. Many physicians have reason to regret their defective education in mathematics, and this can not be supplied in later years.

Natural philosophy, natural history and chemistry should be studied as a preparation for the study of medicine. These subjects are made use of constantly; and there is not time to teach them thoroughly in a medical course. After a boy has learned about as much Latin and Greek as is required for admission to college, he should study the natural sciences. These are becoming more and more important in practice.

The study of anatomy, physiology and hygiene, as these subjects usually are taught in common schools, is a waste of time. A boy who is preparing to study medicine seriously can not afford to engage in a study in which he learns nothing. The ideas that he may get of anatomy and physiology in ordinary schools are in the main crude and incorrect. These subjects belong to medical study, at least for those who intend to become medical students.

Shall a boy who intends to study medicine go through college? In some regards this is not an especially good preparation for scientific studies. The studies in what are called the best colleges seem to turn the mind away from exact scientific knowledge. If a boy has studied what I have tried to indicate, until he is nineteen or twenty, he will have had enough "mental training" to begin to study what will be of use to him in his profession. He will have mental training, also, in his medical studies; and certain subjects, such as anatomy and others which tax the memory, can be learned much more easily at twenty than at twenty-four. If a boy enters college at twenty, is graduated at twenty-four, begins the study of medicine and is graduated at twenty-seven and spends two years in hospitals, he really begins to learn for himself at nearly thirty years of age. Until men have a longer lease of life than threescore and ten, medical students can hardly afford to spend four years at a university.

I strongly advise an American medical student to study his profession in his own country. He can be taught here as well, if not better than abroad. In New York, Philadelphia or Boston, a boy can learn medicine and qualify himself well for practice; but he must have the advantage of large hospitals, and this he can not get in small cities.

When he begins the study of medicine he should enter some good medical college and remain there for the full term of three or four years. During these years, he must work hard all the time. He can not afford to waste a few months here and there and hope to make up the lost time or "cram" so as barely to be able to pass his examinations. He should be made to know, at the very beginning, that a poor doctor is a miserable creature.

If a boy should find himself behind his classmates at the end of his first year, there must be something wrong. He is not the kind of boy wanted for the medical profession, either because he lacks habits of study, is mentally deficient or is not suited to his work. In any case he has made a mistake; and in that event anything is better for him than the profession of medicine.

The bits of advice that I have given are addressed to boys. It is fortunate that most American boys think that they have to make their own way in the world; and if a boy should wish to make his way in the medical profession, he ought to know what to do and what to expect. What he has to do in the study of medicine is plain enough. What he has to expect in the practice of medicine is not so simple a question. He must expect, however, to wait; but the chances are that if he deserves success it will surely come sooner or later.

LII

THE COST OF A MEDICAL EDUCATION IN THE CITY OF NEW YORK

Published in "The Youth's Companion" in March, 1897.

A LITTLE more than eight years ago I wrote an article for "The Youth's Companion," in which I tried to describe "just the boy that's wanted for the medical profession." I am now asked to tell what it will cost such a boy to obtain a medical degree.

I shall not confine myself to the mere legal qualifications for the practice of medicine, as in the case of one who has acquired the minimum of knowledge necessary to enable him to pass his examinations. He may meet with success to the extent of making a fair living, earning some popular confidence and respect; but the aim of a young man preparing himself to enter the medical profession should be to become, when he receives his license, a competent general practitioner and to merit the confidence and respect of his brother physicians. He should be equal to any ordinary emergency, whether medical or surgical. He should know enough of the so-called specialties to appreciate a situation beyond his own practical knowledge and skill and seek competent aid.

At the present day a thoroughly competent oculist, aurist, general practitioner, general surgeon, gynecologist, dermatologist, laryngologist, with a knowledge of other minor specialties, does not and can not exist in the person of any one individual. It is rare, indeed, to find a man of mature knowledge and experience who has, grafted upon his general medical education, a complete mastery of even one of these specialties; and such a man is usually one who enjoys eminent success in his profession as the result of many years of hard work. It is a mistake to begin the

study of medicine with the notion of becoming a specialist. The aim should be to secure first a good general medical education. A specialist who lacks this basis is always narrow, one-sided and an unsafe practitioner or consultant; for there are few local diseases which do not directly or indirectly affect the general system and whose treatment does not call for a knowledge of general medicine.

By the time a student has successfully completed his preparations for the degree of doctor of medicine he will be able to form intelligent plans for his professional future. This article is not intended for physicians; but it is hoped that it may aid those who are about to begin the study of medicine, by giving certain facts in the matter of pecuniary expenditure and sacrifice which must be borne from the time of beginning the study until the degree is received.

Within a year all the medical colleges in New York, as well as all first-class colleges in the United States, will require four years' study of medicine, including four regular courses of college instruction, before the student can receive the degree of M.D. In the State of New York, after receiving the degree, it is necessary to pass the examination of the State Board of Medical Examiners in order to receive a license to practise.

No young man should begin the study of medicine without carefully considering the cost, the length of time which must be devoted to the study and certain matters of a purely personal nature regarding his reasonable prospects of success. First of all he should have at least an inclination toward scientific pursuits and a physical as well as mental capacity for hard study. He should also have a suitable preliminary education, not only sufficient to entitle him to the Medical Student Certificate of the Regents of the University of the State of New York, either by examination or in diplomas or certificates from educational institutions, but a fair knowledge of Latin and perhaps Greek, with mathematics and some knowledge of chemistry and physics. A fair knowledge of Latin is almost a necessity. Without it the names of anatomical parts, diseases, etc., convey no idea, and their acquisition is merely an effort of brute memory. The requirements for a Medical Student Certificate by the Regents are in

many respects imperfect and are not a logical preparation for the study of medicine; but these are requirements provided by law in the State of New York.

There is much in a college education that is suitable as a preparation for medicine; but if a proper education has been acquired, it makes no difference how or where it has been obtained; and a complete college course equips a man with much that is ornamental rather than practically useful. A reading knowledge of French and German is useful; but above all, a student should understand the English language and be able to write correctly if not elegantly.

The minimum of time required for the study of medicine is four years; and it is unwise to begin later than at twenty-five years of age. In an experience in medical teaching and an intimate acquaintance with medical students for an unbroken period of more than forty years, I have seldom met with instances of students who have been able to acquire even a fair medical education without devoting their entire time and energies to the study. Now, more than ever before, it is almost impossible for a student to do justice to himself and be engaged in any other occupation during his courses of instruction or even in vacations. This may discourage some ambitious young men in straitened circumstances; but in the main it is better for the profession and for the young men themselves that they should be thus discouraged.

Beginning study at the age of twenty-five years, a man can hardly expect to be able to enter upon professional life before thirty. This is certainly late enough, especially as all young physicians must look forward to several years of weary waiting before they will be able to earn even a modest living. The cost of a medical education must be looked squarely in the face at the beginning. The college fees in the large schools of New York, Philadelphia and Boston are practically the same; and with rigid economy the cost of living is little if any greater than in smaller cities.

The large cities alone furnish adequate material for demonstration and instruction, with a large field for the selection of efficient teachers; and it follows, almost without saying, that students should go to the large cities to

study medicine. In the large cities the unfortunate poor are skilfully cared for, and they more than repay this care by contributing to the education of physicians and enabling them to relieve the ills of others.

In the city of New York the fees, including everything but books and instruments, amount to about one hundred and eighty dollars for each one of four sessions of six months each. Adding to this the fees for spring sessions of three months each, the total amounts to about two hundred and fifteen dollars for each full year. In some colleges, in which the regular sessions are longer, the total fees are about the same. This includes everything in the way of instruction. These expenditures are what may be called fixed charges, including examinations and the diploma. The graduate, in order to receive the license to practise in this State, must pass in addition the State Board of Medical Examiners and pay a fee of twenty-five dollars. He is then legally qualified to practise medicine.

In my experience I have known students who have successfully completed their medical course at the cost of much sacrifice and self-denial, and at what may be regarded as the minimum of pecuniary expenditure. I have carefully investigated many of these instances, especially the following, which may be taken as a fair example:

A young man with a good preliminary education began the study of medicine, under the three years' system, in 1893. He read under a private preceptor for six months before beginning his college course in the fall of 1893. For this service his preceptor made no charge. His college fees for the first year amounted to one hundred and sixty-five dollars; his board and lodging, two hundred and fifty dollars; books and dissecting-case, twenty dollars; clothing, seventy-five dollars; washing and incidentals, twenty-five dollars; amusements and other incidentals, twenty-five dollars. In his first year he spent five hundred and sixty dollars. During this year he was learning economy by experience. He was able to get a small room with light and heat at one dollar and fifty cents per week. Part of the time he did much of his own cooking over an oil-stove. He found, however, that he could live better and more economically at restaurants on fifty cents a day,

buying commutation tickets. Later, he obtained fair table board at three dollars a week.

The second year was nearly a repetition of the first, with the addition of a fee of fifteen dollars for his "primary" examinations, making his college charges one hundred and eighty dollars. The third and final year was the same, with a charge of fifteen dollars for his final examinations, twenty dollars for laboratory work and twenty dollars for practical work in obstetrics. All these fees were obligatory; but an unexpected remittance enabled him to indulge in one spring course—not obligatory—at an extra expense of forty dollars.

This young man obtained a medical education at a metropolitan school at a total expense, including his support for three years, of a little less than eighteen hundred dollars. In his opinion, based on personal experience, seven hundred and fifty dollars a year is an ample provision, making a total of three thousand dollars for the entire four years, with a reasonable regard for economy.

The small sum estimated for amusements should discourage no one. I am fairly familiar with the natural history and habits of the medical student. A college class of four or five hundred divides itself into those who work hard and enthusiastically, those who take a moderate interest in their studies, but are led away more or less by social and other distractions and amusements and those who are indifferent and do little or nothing.

The enthusiastic workers keep by themselves and practically ignore the others. They are the most contented and the happiest men in the class; and most of them have a full, if not an exaggerated appreciation of their own importance and acquirements, which, however, in their early professional life, usually becomes reduced to reasonable limits. These men take all the competitive hospital appointments and all the prizes. A student has only to be a worker and of fair intelligence to be admitted to this circle, provided he has no obtrusively disagreeable traits of character.

To return to amusements: The good students find enough distractions in the line of their student life. While dissecting, which occupies them closely for three periods of about three weeks each during the session, every

evening is occupied from about eight to ten o'clock, and after that hour they are glad enough to go quietly to bed. When not actually dissecting, they usually spend the evenings in the dissecting-room or in studying together in groups.

During the last two years students do not dissect, and it is common for them to form little clubs of ten or twelve, meeting in the evenings, and "quizzing" on the subjects of the lectures, each one taking his turn. I venture to say that there is no physician who has been a good medical student who does not look back upon his college course as the happiest period in his life.

I can not properly close without giving my observation in regard to the degree of intelligence which a student must have to enable him to attain the degree of M.D. Ten or fifteen years ago, when most of the colleges required only two winter courses of lectures, I could say that no one, beginning with a fair education, could fail to attain his degree if he faithfully did his work; but this is not true at the present day. What is required of students now is very much greater; and I know students who have worked hard during their entire college course, but have not been able to pass their examinations, and who could never succeed, with any amount of study and cramming. These congenital defects are brought out during the first year, and it is wise for students or their friends to recognize them and act accordingly; but an intelligent young man, with a suitable preliminary education and good health, at the cost of four years of hard work and three thousand dollars in hard cash, can secure a medical education in the city of New York.

LIII

THE OPEN DOOR OF QUACKERY

Published in "The North American Review" for October, 1889.

It is not putting the statement too strongly to say that in the United States the door is open to quackery wider than in any other civilized country. As we, as a nation, become older, our people are more and more efficiently protected against public dangers of various kinds, such as the unrestricted sale of poisons, the erection of unsanitary and unsafe buildings and the many acts of violence that occur in newly-settled regions. It is time, at last, for the medical profession to make a united effort to protect the people against quackery; for the disjointed, spasmodic and crude attempts that have been made in this direction have resulted in but little good except in a few States. Every physician knows that absolute protection is impossible. Many unfortunates, afflicted with incurable or tedious chronic diseases, grasp at anything that offers hope of relief, whether it is a remedy recommended by a sympathizing friend or a cure advertised in the secular press. Unhappily, the demand for panaceas and for the services of those who claim to cure by extraordinary means is not confined to those who are deficient in intelligence or weakened and discouraged by exhausting diseases. So long as the love of the marvellous exists, so long will there be a certain demand for quackery, and the supply will not entirely fail.

A plan for relief from the evils of quackery should emanate from the medical profession. Of course, the ideal remedy is in an intelligent regulation of the practice of medicine by the general government; but I shall dismiss this with the statement that in my opinion it is impossible. Nearly the same result, however, would fol-

low if concerted and uniform action could be taken simultaneously by all the States.

It is difficult to accomplish much good so long as serious antagonism exists between the colleges and any respectable part of the general profession; but I think that whatever antagonism exists might be harmonized upon a basis of well-considered and judicious legislation. The influential colleges must coöperate with the profession at large or failure is probable. An experience of more than thirty years in medical teaching and much thought devoted to the question have led me to certain definite ideas concerning practical and practicable measures for the elevation by legislation of the standard of acquirement in the medical profession. It seems to me that if a comprehensive act were passed in the State of New York, which would evidently accomplish the ends so much to be desired, but little effort would be required to secure the adoption of similar acts in other States, and that practical uniformity of medical laws in all the States of the Union would be the final result. I shall first outline what, it seems to me, would be a proper act, and afterward give my reasons for certain of its provisions.

I. The regents of the University of the State of New York to appoint a board of medical examiners, to consist of fourteen members, seven to be nominated by the unsectarian medical colleges empowered to confer the degree of M.D. in the State of New York, and to be teachers in said colleges, and seven to be nominated by the unsectarian State medical societies; the board to be so constituted that there shall be two examiners for each of the seven subjects of practice of medicine, surgery, obstetrics, materia medica and therapeutics, physiology, anatomy, chemistry and the collateral branches.

II. After a certain date, no person to be permitted to practise medicine who has not received a license from the boards of examiners, with the following exceptions:

(a) Physicians registered up to the date mentioned.

(b) Physicians from other States and from foreign countries who hold licenses from boards of examiners, the requirements of which are in no degree less than those of the board of examiners of the State of New York; such licenses to be examined and endorsed by one of the med-

ical colleges of the State of New York and certified to as meeting the requirements of the board of medical examiners.

III. The board of examiners to recognize, in their examinations, but one science of medicine; but no candidate to be rejected by reason of his adherence to any sectarian system, such as homœopathy, provided that he passes the regular examination of the board.

IV. A candidate to be eligible to appear for examination before the board, if he produces a diploma from an incorporated medical college of the State of New York or from a recognized medical college, not in the State of New York, the requirements of which were in no degree less than those of the medical colleges of the State of New York at the time when the diploma was issued.

V. The votes on candidates to be by the seven subjects before enumerated, and two adverse votes of the seven to reject a candidate; provided that no candidate shall be licensed who receives an adverse vote in either one of the subjects of practice of medicine, surgery or obstetrics.

VI. A candidate who has been rejected not to be eligible for reëxamination until at least six months shall have elapsed since his rejection; but the reëxamination, at the discretion of the board, may be upon those subjects only in which he has failed to pass in his previous examinations.

VII. In voting on candidates, no vote on any subject to be accepted as affirmative unless both examiners on that subject shall have agreed. In case of disagreement, the vote to be regarded as adverse; provided that when but one examiner is present at the examination he may cast an affirmative or a negative vote, and that, when neither examiner is present, another member of the board may be assigned to examine, and his vote shall be received.

VIII. The board to have the power to revoke the license of any physician for certain causes, such as conviction of crime, grossly unprofessional conduct, etc.

After a certain date, the following to be the requirements of the medical colleges in the State of New York:

1. A matriculation examination, made within the first

thirty days of the regular session or before, for those who have not a degree of A.B., B. S. or Ph.D., provided that equivalent matriculation examinations from other recognized colleges may be accepted.

2. An obligatory three-years' course, each course to be of not less than twenty-two weeks' duration, and no two courses to be taken within a single year.

3. At least two courses of dissections.

4. At least one course of laboratory work in chemistry.

5. At least one practical course in normal and pathological histology.

6. At least one clinical course each, with practical exercises, in practice of medicine, surgery and gynecology, of not less than twenty-two weeks' duration.

7. Colleges to make yearly complete and detailed reports to the Regents of the University.

8. If it shall appear at any time that the provisions of the law in regard to medical colleges have been wilfully violated, it shall be the duty of the regents to recommend to the Legislature that the charter of the offending college be revoked.

In my opinion, it would be possible, if the unsectarian colleges of the State of New York would meet in convention, to frame a comprehensive bill which would be satisfactory to the profession and would measurably protect the people against professional incompetence and quackery. If such a bill should be endorsed by the State medical societies and introduced under the auspices of the Regents of the University, it probably would be passed.

There are certain points in the constitution of the board of examiners which I think the profession should insist upon. In no examining boards abroad is there a recognition of any sect in medicine. While it may be wise to provide that no candidate for a license shall be rejected by reason of any peculiar views which he may adopt, there is but one science of medicine. A so-called regular physician has the largest latitude of opinion; and he continues to rank as a regular physician so long as he adopts no sectarian designation. No man should be licensed to practise before he has shown by examination a certain proficiency in medicine. It remains with himself afterward either to adopt any designation, to advertise or employ

any of the methods of the charlatan or to practise simply as a physician. It is worse than absurd to exclude from examining boards professors in medical colleges. No one with any considerable experience in teaching and examining can fail to know that the most competent examiners are teachers. In a science the progress of which is so rapid the chances are that those most likely to be fully informed in regard to recent advances which students should be expected to know, are teachers; and it is a gratuitous insult to professors in medical colleges to assume that they would be likely to act unfairly in examinations. It is proper, however, that in functions so important, the general profession should be represented, as in having the examinations conducted jointly by two persons in each subject, one of these not being a professor.

The same argument may be applied to the requirement that candidates shall already have passed an examination and been graduated by a medical college. This would certainly secure a higher grade of attainment than if candidates were examined by the medical board only. The requirement of a certain number of years of instruction is also essential. The medical department of the University of Virginia will graduate students after only nine months of study. I think it may be safely assumed that no student can be properly educated in medicine within that time. Under the existing conditions in this country three years of medical study seem to be sufficient. Students here do more work and less play than abroad; the teaching and drilling in the schools are more efficient; and finally the report of the president of Harvard University on the optional four-years' course in the medical school does not show that students who have taken that course are better educated than those who have been graduated in three years. Study after graduation and not with direct bearing on examinations seems to produce better results in most instances than a lengthened course before graduation.

One of the most desirable and at the same time difficult things to secure is uniform legislation in the different States. A reciprocity of action will do much to promote this object, and with this in view, a recognition of licenses issued by examining boards of other States, the require-

ments of which are not less stringent than those of the New York board, should be provided for. Foreign credentials, also, from boards fully equal in their requirements to the New York board, should be recognized.

I fully agree that there are few medical colleges in the United States in which the teaching is so thorough and efficient as it is in Great Britain, France or Germany; still there are some in which the instruction is in certain regards even superior to what is found abroad. Many of the smaller colleges, however, are beneath contempt, and their inefficiency is simply disgraceful; while at the same time, they publish in their circulars the most elaborate and high-sounding methods and requirements. The four medical colleges in Washington hold their lectures in the evening for the convenience of students who are at work in the Departments during the day. Were certain colleges to form an association and refuse to recognize the tickets and diplomas of institutions which do not come up to a proper standard of efficiency, most of these disreputable organizations would cease to exist.

NOTE.—It is almost unnecessary to say that at the present time, thirteen years after this article was written, the advances in actual knowledge in medicine, surgery and pathology have been so great that four years of study is none too long, in view of the laboratory and clinical work necessary to fit a student for the practice of his profession.

LIV

A POSSIBLE REVOLUTION IN MEDICINE

Published in " The Forum " for December, 1888.

More than two hundred years ago (1675), Leeuwenhoek discovered what he called little animals, or animalcules, in " rain, well, sea and snow water; as also in water wherein pepper had lain infused." These were microscopic, but of large size as compared with the objects now generally known as bacteria. The organisms seen by Leeuwenhoek were animalcules; the bacteria are vegetable growths. The rude and imperfect lenses used by Leeuwenhoek restricted his observations within very narrow limits, which were gradually extended as optical art advanced, following the invention of achromatic lenses in the middle of the eighteenth century. The recent construction of homogeneous oil-immersion lenses, and the use of achromatic condensers, particularly those known as the Abbe condensers, have rendered possible a successful study of the more delicate forms of microörganisms. Comparing recent discoveries in bacteriology by means of perfected microscopical apparatus with discoveries in astronomy by the use of the great telescopes, it seems that the small has the advantage over the great, at least so far as advances in knowledge have influenced the happiness and welfare of the human race. The science and practice of medicine and surgery are undergoing a revolution of such magnitude and importance that its limits can hardly be conceived. Looking into the future in the light of recent discoveries, it does not seem impossible that a time may come when the cause of every infectious disease will be known; when all such diseases will be preventable or easily curable; when protection can be afforded against all diseases, such as scarlet fever, measles, yellow fever,

whooping cough, etc., in which one attack secures immunity from subsequent contagion; when, in short, no constitutional disease will be incurable and such scourges as epidemics will be unknown. These results, indeed, may be but a small part of what will follow discoveries in bacteriology. The higher the plane of actual knowledge, the more extended is the horizon—"Plus on s'élève, plus l'horizon s'étend." What has been accomplished within the past ten years, as regards knowledge of the causes, prevention and treatment of disease, far transcends what would have been regarded a quarter of a century ago as wild and impossible speculation.

What, one may well inquire, has occurred within the past few years to justify expressions apparently so extravagant? Simply an unusually rapid evolution of knowledge from researches which at the time seemed of comparatively little pathological importance, such as Pasteur's experiments on the fermentations. Pasteur's discovery of the microbe which produces a peculiar disease in silkworms, and especially the isolation of the microbe of the carbuncular disease of sheep, which sometimes attacks man, gave a powerful impulse to the study of bacteriology. It became evident that a complete separation of different forms of bacteria was a condition essential to their accurate study. It was also necessary to ascertain the mode of multiplication of different bacteria. In the forms of microörganisms that produce disease, called pathogenic, the characteristic disease is coincident with their presence in immense numbers in the body. The methods of investigation by which successful modern observations have been made were brought practically to their present degree of perfection by Koch. It seems to me that a brief description of these methods can hardly fail to be of general interest. In what is to follow, the disease-producing organisms will be called bacteria, microbes or microörganisms. These names, however, which will be used synonymously, embrace many forms that are not pathogenic.

In modern bacteriology the first condition to secure is absolute sterilization of all the media and apparatus employed. This simply means destruction of all microbes present. The test-tubes and other glasses and instruments are heated to a temperature which will kill any

germs that may be attached to them, and are carefully protected as they are allowed to become cool. The water used is sterilized by prolonged boiling. The nutrient substances in which the bacteria are to be cultivated are sterilized in a similar manner, but not by prolonged boiling, which would prevent the solidification of gelatiniform substances. The hands are not allowed to touch anything that it is necessary to keep free from contamination with extraneous organisms. Finally, the air admitted to the cultures is filtered through sterilized cotton or some substance that will arrest floating germs.

The next step is to prepare a medium in which the microörganism which it is desired to cultivate will readily multiply. While this is easy, other microörganisms will multiply as well; and a difficult problem has been to separate the different microbes from one another and to obtain what are known as pure cultures. A pure culture is a so-called colony of a single form of bacteria. If proper precautions have been taken, no extraneous microörganisms are present in the apparatus used or in the culture-media; but in cultivating any one form of microbe, such as the bacteria of Asiatic cholera, other organisms invariably exist in the material from which the special form is to be obtained or isolated. An account of the attempts that have been made to isolate different forms of microbes, from the early experiments of Pasteur to the more successful efforts of Koch, would make a long chapter in the history of bacteriology and would be out of place here; but the results of recent labors have laid the foundation of accurate knowledge of the relations of bacteria to certain diseases.

Koch prepared a gelatin, called "nutrient gelatin," possessing the properties of solidity and transparency. If a drop of fluid containing a number of different bacteria is diffused through this while the culture-medium is liquid, and the mixture is then solidified by cooling, each different microbe becomes isolated by a surrounding layer of gelatin, and from each one, by its multiplication, a colony is produced within a few hours, which can be recognized by means of a low magnifying power. From any one of these colonies microbes may be taken on a sterilized platinum wire, and "inoculated" upon a fresh culture-medium. A

new colony will then be formed, and this process may be repeated. In this way an absolutely pure culture may be obtained. Nutrient gelatin is by no means the only culture-medium employed in bacteriological research. With some forms of bacteria, agar-agar (a substance resembling isinglass), prepared blood-serum, etc., present peculiarly favorable conditions for growth. The process of multiplication of bacteria is either by transverse division or by spores, which latter are much more difficult to destroy than bacteria themselves.

Having obtained pure cultures of different bacteria from the blood or from altered anatomical structures in any special disease, it is necessary to fix upon one form that is invariably present in that disease, and if possible to show that the disease may be produced by inoculation of a healthy animal with the isolated microörganism. It has not been possible, up to this time, to obtain this absolute proof of the causative relation of certain bacteria to diseases. For example, no inferior animal has been found to be susceptible to typhoid fever; but a microörganism, called the typhoid bacillus, is constantly found in the intestines in cases of typhoid fever and in no other disease; and this is true of many diseases that are due undoubtedly to bacteria. On the other hand, however, tuberculosis, relapsing fever, glanders, erysipelas and certain diseases of the inferior animals have been produced by inoculation with pure cultures of bacteria found in these diseases and characteristic of them.

The minute size of many bacteria and the lines and shadows produced by the refraction of light as it passes through them render it difficult, and in many instances impossible to recognize them even under the most perfect illumination and with the best modern lenses. The old forms of dry objectives are almost useless in bacteriological investigations; but the homogeneous oil-immersion lenses, with the object illuminated by means of the Abbe condenser, suffice for the recognition of all known forms of bacteria after they have been treated with staining preparations. The perfection of staining processes, which for some time had been used in anatomical research, is largely due to Koch. Without entering into a full description of the use of staining agents in bacteriology, it is suffi-

cient to state that bacteria are distinguished from normal anatomical structures; first, by the greater resistance which the former present to the action of acids and alkalies, and second, by the certainty and rapidity with which bacteria take up some of the aniline dyes. The resistance of bacteria to acids and alkalies renders it possible to decolorize other structures found in microscopical preparations, leaving the stained bacteria practically intact. Thus, the staining of bacteria enables the observer to recognize them as bacteria; but different forms of microörganisms behave differently in the presence of the same or different staining reagents. However, the aniline dyes enable one to distinguish all forms of bacteria from minute bodies with which unstained bacteria might be confounded.

From this short account the reader can form an idea of what bacteria are and how they have been investigated. It is now almost universally admitted that they are vegetable and not animal organisms. The different forms are distinguishable by their appearance under the microscope, their behavior in the presence of staining reagents, their modes of multiplication, the time and manner of production of colonies from single germs placed in culture-media and other characters which need not be enumerated. Within the few years that bacteria have been closely studied, immense numbers of microörganisms have been discovered; but the larger proportion of these embraces organisms that are innocuous, and comparatively few have been recognized as pathogenic, or disease-producing.

It is probable that future investigations into the physiology of digestion will show that bacteria play an important part in this function. Pasteur has recently isolated no less than seventeen different microörganisms in the mouth, which were not destroyed by the gastric juice. Some of these dissolved albumin, gluten and casein, and some changed starch into sugar. Bacteria normally exist in great number and variety in the intestines, although the part which they take in intestinal digestion has not been determined. It has been ascertained, however, that the intestinal microörganisms produce certain substances which have been regarded as putrefactive, and that the action of these products is to kill the microörganisms and thus to limit the putrefactive processes.

In the practice of medicine recent discoveries in bacteriology have brought about changes which amount almost to a revolution. In certain diseases, among which are tuberculosis, pneumonia, erysipelas, carbuncle, diphtheria, typhoid fever, yellow fever, relapsing fever, malarial fevers, certain catarrhs, tetanus, nearly all contagious diseases, a great number of skin affections, etc., the causative action of bacteria can no longer be doubted. The conditions necessary to the development of these diseases seem to be a susceptibility on the part of the individual and the lodgment and multiplication of special bacteria in the system. Some persons are insusceptible to certain infections in the ordinary way, while others present a peculiar susceptibility to certain diseases, which in some instances is inherited. It is probable that a person with an inherited tendency to consumption would never develop the disease if he could be absolutely protected against infection with the tubercle bacillus; but once infected, the bacteria multiply and produce the characteristic signs and symptoms. In other persons the bacillus tuberculosis with difficulty finds a lodgment and multiplies slowly. Many of the lower animals are susceptible to tuberculosis; and the disease has often been produced by direct inoculation with a pure culture of the tubercle bacillus. In the light of modern discoveries consumption can no longer be regarded as an incurable disease. In certain cases the bacteria, if confined to the lungs, may be destroyed; and it has been observed that as the characteristic microörganisms disappear from the sputum, the characteristic symptoms pass away and patients gain in weight and strength. The problem in the treatment of diseases due to the action of pathogenic bacteria is to destroy the bacteria or their products without destroying the patient. It is by no means impossible that such measures will be discovered applicable to all diseases that are dependent upon known forms of bacteria.

In certain diseases, such as the eruptive fevers, the time of reception of the contagion may be accurately determined. These diseases have a known period of incubation, or hatching, which resembles the incubation of bacteria when inoculated on a culture-medium. During this period, when there are no symptoms, the bacteria are slowly multiplying but are still confined to certain restricted

situations. They soon become so abundant, however, that they are distributed in the system and the characteristic symptoms of the disease make their appearance; but after a certain time the organisms are destroyed and the disease disappears. In many such diseases the individual affected becomes afterward insusceptible to contagion. Is it not reasonable to hope that methods of treatment will be discovered by which the germs may be destroyed during the period of incubation, or the disease cut short even after it has become fully developed! It is not known why a person who has passed through a certain disease is protected against a recurrence of the contagion, but this is the fact. It is not beyond the range of probability that the immunity acquired by passing through the disease may be produced by other means. It is assumed that all diseases produced by microörganisms are infectious. If the cause of every infectious disease were discovered, it would not be too much to expect to find eventually means for its cure, its prevention during incubation or protection against its attacks.

It is probable that all the virulent diseases, such as rabies, are due to the direct inoculation of bacteria. In all of these there is a period of incubation in which, probably, bacteria are multiplying at the site of the wound. When the colonies of microörganisms are so large that the bacteria or their products find their way into the circulation, the disease is developed; but even a considerable time after inoculation, the germs may be removed by excision or destroyed by local applications, and the disease be prevented. It is probable that bacteria, although they produce infection, are not actually the poisonous agents which give rise to the characteristic phenomena of infectious diseases. In some way the pathogenic bacteria produce substances similar to alkaloids, which are poisonous. These products are called "ptomaines." They have not been obtained from many of the pathogenic bacteria, and, indeed, the study of these toxic agents is still in its infancy; but the production of a ptomaine from pure cultures of the cholera bacillus, which, it is said, gives rise to choleraic symptoms when injected into the body of certain of the lower animals, the production of tetanin from cultures of the tetanus bacillus, and other recent researches,

render it probable that each form of pathogenic bacteria produces a peculiar toxic ptomaine.

A rational treatment of disease, based on a knowledge of the mechanism of infection, is not a thing entirely of the future. Fermentative indigestions are successfully treated with what are now known as disinfectants; in many instances the bacteria of consumption may be destroyed; various skin diseases are cured by killing the organisms which produce them; diphtheria is sometimes cut short by attacking the germs on the mucous membranes; and such examples might be multiplied.

An account of the relations of bacteria to disease, however brief, should include the remarkable results which have followed the introduction by Lister, about 1860, of antisepsis in surgery. Nine or more different forms of bacteria have been distinguished in pus. Some of these, as well as other forms which produce pyemia, hospital gangrene, septicemia and other conditions which sometimes follow surgical operations, are developed from germs floating in the atmosphere or attached to surgical instruments, sponges, dressings, etc. Lister was the first to perform surgical operations under conditions which precluded the possibility of infection of wounds by microörganisms; but his early methods were cumbrous and difficult. The technique of surgical operations at the present day is simple enough but is absolutely antiseptic. Every instrument used is kept in a tray filled with a solution containing carbolic acid in the proportion of one part to about forty of water. The sponges are thoroughly cleaned and disinfected. The ligatures, after having been boiled in an antiseptic fluid, are kept in this fluid until used. All bandages and other dressings are made thoroughly antiseptic. The hands of the operator and of his assistants are thoroughly disinfected and are dipped from time to time in a carbolic-acid solution. The part to be operated upon is shaved and then scrubbed with soap and washed with an antiseptic solution. It is also isolated from the rest of the body by cloths wrung out in an antiseptic fluid, so that only this part is exposed. An assistant follows the knife of the surgeon with a stream of antiseptic liquid. When the operation has been completed, the wounds are closed and thoroughly protected by antiseptic dressings. Anti-

septic drainage-tubes are introduced, when necessary, to carry off discharges. The general result of these precautions, which are now taken in all well-appointed hospitals and are employed by all good surgeons, are an absolute protection of wounds against purulent and other infections and an elimination of nearly every danger that may attend surgical operations, except shock. The elimination of these dangers, by thorough antisepsis, has enabled surgeons successfully to perform operations of a magnitude that would have appalled an operator of the olden time. Indeed, the revolution in surgery since 1860 has been more complete even than in practical medicine.

This brief sketch of the progress in medical and surgical methods due to bacteriological studies was not written for the professional reader, and its subject has been treated from the stand-point of a practical physician only. I venture to say that few persons who have not closely followed the work of modern pathologists have any definite ideas in regard to bacteria, what they are, how they are developed and what their importance is in Nature. Bacteria are everywhere. They abound in the earth, in water, in nearly all kinds of food and in many of the animal fluids; their germs exist even in the atmosphere; but it must be remembered that of the immense number and variety of these microörganisms, very few only are toxic or are capable of producing toxic substances. If what is known of the relations of bacteria to disease can justify even a small part of the speculations in regard to the possible results of future investigations, our present knowledge of the relations of microörganisms to digestion, to the growth of plants, to the changes of matter involved in putrefaction and to all kinds of fermentation opens a field for the imagination that seems truly illimitable.

NOTE.—The predictions in this article, in regard to immunizing agents, made fourteen years ago, have since been abundantly verified. (November, 1902.)

LV

THE REVOLUTION IN MEDICINE

Published in "The Forum" for January, 1891.

IN an article entitled "A Possible Revolution in Medicine," published in "The Forum" for December, 1888, I wrote as follows:

"The science and practice of medicine and surgery are undergoing a revolution of such magnitude and importance that its limits can hardly be conceived. Looking into the future in the light of recent discoveries, it does not seem impossible that a time may come when the cause of every infectious disease will be known; when all such diseases will be preventable or easily curable; when protection can be afforded against all diseases such as scarlet fever, measles, yellow fever, whooping cough, etc., in which one attack secures immunity from subsequent contagion; when, in short, no constitutional disease will be incurable and such scourges as epidemics will be unknown."

The reflections embodied in this quotation arose mainly from the discovery of the bacterial origin of consumption by Koch. Far from seeming to me extravagant, the words just quoted failed to express the possibilities as they appeared to my mind; and I believed that the problem of destroying the bacteria or their products without killing the patient would be solved in the near future. The first steps, at least, of its solution are apparent. While data for an exact appreciation of the cure for consumption proposed by Koch are by no means complete, sufficient facts exist to warrant a discussion of the subject at the present time. The unprofessional reader should understand that Koch, mainly by reason of his discovery of the cause of consumption, has for several years been the most prominent figure in medical science known in our generation. His methods have been models of scientific accuracy and the authority of his statements is now almost

unquestioned. When he announces to the world that he has apparently cured a certain class of cases of one of the most formidable and destructive diseases that afflict the human race, he awakens an interest that is by no means confined to the medical profession. I shall attempt to give the essence of this discovery, so far as it has as yet been made known; but I must fill in from my own mind what seems to me to be the rationale of the processes employed. If I am measurably correct in my ideas of the processes of cure, humanity has never received from science so great a boon; and tuberculosis will not long be the only grave disease successfully combated by Koch's method.

In an article published by Koch simultaneously in this country and in Germany, on November 14, 1890, the details of the new treatment of several forms of tuberculosis are given. In a Berlin paper, six days later, is a description of the mode of preparation of the "curative lymph." The latter, in all probability, is substantially correct; at least, no correction or contradiction has thus far appeared, and the method is essentially the one that is employed in obtaining poisonous products from other toxic bacilli. The method, as described, consists in placing in an incubating apparatus a pure culture of tubercle bacilli in gelatinized beef broth. The apparatus is divided into an upper and a lower portion by a diaphragm of unglazed porcelain, the bacilli being placed in the upper compartment. In the course of time the gelatin liquefies, and a liquid slowly filters through the porcelain into the lower compartment. This liquid is the curative lymph. The lymph thus obtained may contain a ptomaine, although the tubercle ptomaine, if it exists, has never before been found. Certain ptomaines are obtained from microörganisms by methods resembling that just described. The toxic ptomaines are produced by toxic bacilli; and these are supposed to be the direct cause of various diseases, the bacilli being toxic only in so far as they produce these ptomaines. As very many bacilli are not toxic, many ptomaines have no poisonous properties. Probably the production of ptomaines is limited; and in the case of toxic bacilli, those that have produced ptomaines in the body are thrown off, after having to a greater or less extent damaged the parts in which

they have been lodged; but the organisms thus thrown off, if they find a lodgment in another body, may multiply, produce ptomaines again and repeat the processes just described. It is in this way that certain diseases are propagated by contagion.

From the meagre and disconnected reports that come from Europe, it appears that analysis of the lymph has failed to reveal the presence of a ptomaine chemically considered; but the lymph certainly contains one or more substances capable of producing certain of the effects of toxic ptomaines. However, the chemistry of the ptomaines is in its infancy; and we must await exact and elaborate researches before it will be possible to decide on the composition and properties of the lymph obtained by Koch. The statements made by Koch himself are of a character fully to justify the profound impression they have made on the public as well as on the medical profession. Koch's previous career entitles his utterances to a most respectful consideration. A few years since, he discovered the cause of tuberculosis; and this discovery at the present day has no scientific opposition worthy of serious consideration. He now states that he probably has discovered a cure for tuberculosis. I can not but think that this also will soon become an acknowledged fact.

The lymph used by Koch is simply injected beneath the skin. It undoubtedly acts through the blood, but it has no effect when taken into the stomach. When introduced with proper antiseptic precautions, no effects are observed at the point of injection. The general effects are much more marked in the human subject than in the inferior animals, notably the Guinea pig, which is the animal most frequently experimented upon. Making allowance for differences in body-weight, "one fifteen-thousandth part of the quantity which has no appreciable effect on the Guinea pig, acts powerfully on the human being." When the lymph is injected in a full dose into the arm of a healthy person, in three or four hours there is pain in the limbs, with tendency to cough, a feeling of fatigue and difficulty in breathing. These symptoms continue for one or two hours; then follows a severe chill, with nausea, vomiting, and a rise of nearly five degrees in temperature. The symptoms begin to abate after about twelve hours

and then rapidly disappear. These phenomena constitute what Koch calls the "reaction" produced by the remedy. A most remarkable fact developed in Koch's experiments is that a dose of 0.01 cubic centimetre (one-sixth of a grain) injected under the skin of a healthy person, or of one suffering from any non-tuberculous disease, produces no reaction, but that an equal dose "injected subcutaneously into tuberculous patients, causes a severe general reaction as well as a local one."

After a number of experiments on animals and on his own person, Koch employed his remedy in cases of tuberculosis. His first observations seem to have been made on patients suffering from lupus, a tuberculous ulceration of the skin and subjacent parts, which is much more common in Germany than in this country. This disease, known as "lupus exedens" when it spreads rapidly, is supposed to be due to the tubercle bacillus, which multiplies and extends, destroying the parts involved. The most successful treatment that has hitherto been employed has been to scrape away the diseased tissue and to dress with antiseptic solutions, and in this way to remove or destroy the bacilli. A few hours after injection of the remedy into any part whatever under the skin, the characteristic general reaction is produced. During the fever the diseased parts become apparently inflamed and the "lupus tissue becomes brownish and necrotic." After the fever has subsided the swelling decreases, and the growth becomes covered with a crust which falls off in two or three weeks and leaves a healthy cicatrix. Sometimes one injection will effect a cure, but usually several are required. The phenomena are most striking in external tuberculosis, where the local processes can be watched; but it is thought by Koch that similar processes take place in tuberculosis of the glands, bones, joints, lungs and other internal parts.

In cases of pulmonary tuberculosis, commonly called consumption, the action of the remedy possesses the greatest interest and importance. Statistics show that about ten per cent. of recorded deaths at all ages and from all causes are due to consumption. In England, for the fifty years immediately preceding the adoption of vaccination, which occurred about the year 1800, small-pox

contributed about ten per cent. to the total of deaths from all causes. In 1887 the proportion of deaths from small-pox was one-tenth of one per cent. Comment on this comparison is unnecessary. Consumption is primarily due to a deposit of tuberculous matter in the lungs. The deposition of tuberculous matter, its softening and its discharge by expectoration constitute the first stage. When cavities have been formed, the disease is said to be in its second stage. These two stages may coexist, either in different parts of the same lung or in the two lungs. The results of treatment by Koch can best be given in his own words:

> "Patients under treatment for the first stage of phthisis (consumption) were freed from every symptom of disease and might be pronounced cured; patients with cavities not yet too highly developed improved considerably and were almost cured; and only in those whose lungs contained many large cavities could no improvement be proved. Objectively, even in these cases the expectoration decreased and the subjective condition improved. These experiments lead me to suppose that phthisis in the beginning can be cured with certainty by this remedy. This statement requires limitation in so far as no conclusive experiments can possibly be brought forward at present to prove whether the cure is lasting."

It was found that patients with consumption reacted strongly to a small dose of the remedy—less than one-hundredth part of the dose that is required to produce a strong reaction in a healthy person; but as the improvement progressed, larger doses could be tolerated, and when the cure was complete, patients reacted only to the doses required by non-tuberculous persons. In the progress of the cure, the cough and expectoration, which were immediately increased after the first injection, gradually diminished; the matter expectorated became less purulent in its appearance and contained fewer bacilli; the bacilli gradually disappeared; the cough ceased; and within five or six weeks the patients increased in weight. The remarkable fact that consumptives react to a dose of lymph two hundred times smaller than that required to produce the characteristic effects in the non-tuberculous, led Koch to attach great importance to the injections as a means of diagnosis. There are cases in which diagnosis is difficult and uncertain by ordinary methods of exploration, and in which bacilli can not be discovered in the expec-

toration. According to Koch, if there is a strong reaction to 0.002 cubic centimetre (one thirty-second of a grain), it is certain that the patient is affected with tuberculosis; while the reverse is true if the required dose is equivalent to that which will produce the characteristic reaction in non-tuberculous persons.

It may safely be assumed that every statement made by Koch himself is true and accurate. He has gone no farther than is justified by the facts. With this assumption no one can doubt that Koch has made one of the most important discoveries in the history of medicine; though one who had read the article, "A Possible Revolution in Medicine," even with the enthusiasm of the writer, could hardly have imagined that the revolution could come so soon. If it is true that "phthisis in the beginning can be cured with certainty," it is possible that consumption may be cured in the later stages by supplementing the injections with general hygienic measures of treatment, antiseptic inhalations and other methods that have been found useful. I have not intended to take up the question of preventive inoculation. Although tuberculosis is communicable, it is not so actively contagious as to lead to general inoculation for its prevention. The experiments that have been made in this direction have probably had for their final aim the discovery of a cure for the disease. The direct value of the discovery of a means of curing a disease which is responsible for one-tenth of the deaths from all causes, including violence, is indeed great; but the imagination almost fails to grasp the importance that the method would have if it should be extended to other diseases produced by microörganisms. If we know the exact mechanism of the cure for consumption, it is certain that we shall soon be able successfully to apply this knowledge to the study of other diseases. Speculation and theory necessarily precede intelligent observation and experiment. As a basis for speculation, however, ascertained facts are most useful.

What are the pathological processes which take place in consumption? If an individual has an hereditary or other predisposition to the disease, the tubercle bacillus, when it finds its way into the lungs, meets with conditions

favorable to its multiplication. Some individuals acquire the disease in this way; others are able to resist infection. Once fixed in the lungs, the bacillus multiplies and invades the pulmonary structure. After a time it produces something—whether this is a ptomaine or not is practically immaterial—and this product acts as a poison to the general system. Among the effects of this poison is elevation of the body-heat. There is no case of progressive tuberculosis without increased temperature. A reduction of the temperature to the normal standard is evidence that for the time the malady is not progressive, and the increase in temperature is a measure of the activity of the disease. The increase in temperature is due to the poison produced by the bacillus and not to the bacillus itself.

Does the poison produced by the bacillus destroy the bacillus itself? This question can not be answered positively, but it is almost certain that the bacilli can not produce the poison indefinitely. In the course of the disease bacilli are thrown off by expectoration. If no new colonies should be formed, the products of the bacilli might actually cure the disease; but it is probable that in most cases bacilli are transferred from one lung to the other, or from one part to another of the same lung, and that thus the disease is kept alive by auto-infection, the bacilli being able to multiply and to produce the poison again in each new nidus in which they may find lodgment. Still, there are cases in which consumption seems to be self-limited, in which it seems to cure itself, probably by the action of the poisonous products of the bacilli in throwing off the bacilli or in destroying the tuberculous tissue. The theory that certain cases of consumption, observed without any medicinal treatment, illustrated the law of self-limitation, was advanced by the late Dr. Austin Flint in 1858, and was maintained by him in his latest writings.

Koch's idea in regard to the action of his curative lymph is that "the remedy does not kill the tubercle bacilli, but the tuberculous tissue." The bacilli that are constantly thrown off in progressive cases of consumption certainly are not killed, for they will produce consumption if inoculated; and even when dried and inhaled they will give rise to the disease. Possibly the statement by Koch

that the remedy destroys tuberculous tissue may include the idea that it renders the tissue in which the bacilli are lodged unfit for their development and multiplication and for the production of their special poison. It may be that there is a conflict between the bacilli and their own poison, that the poison has a tendency to dislodge the bacilli and that this dislodgment is not complete if the bacilli multiply so fast that they overcome this influence. A logical way to dislodge the bacilli and to throw off the tuberculous tissue would be to reinforce the poison by introducing it into the system. This idea may explain Koch's curative process. He adds the poison without adding bacilli. The poison exists in a certain quantity in tuberculous patients and produces elevation of temperature and other symptoms; but the multiplication of bacilli from new points of auto-infection is so rapid that the disease progresses. A healthy person can tolerate 0.25 cubic centimetre (four grains) of the poison introduced by subcutaneous injection; but a tuberculous patient, who already has the poison in the system, can bear but little in addition, and 0.002, or even 0.001, cubic centimetre (one thirty-second, or one sixty-fourth of a grain), is sufficient to produce a strong reaction.

It is probable that an active agent in Koch's lymph is essentially the same as the poison produced by tubercle bacilli in the human body and is a product of tubercle bacilli, which, it may be assumed, grow in Koch's culture medium in the same way that they grow in the lungs and generate the same product or products. The reaction described by Koch is analogous to the phenomena produced by the tuberculous poison in consumption. If these ideas are in the main correct, it is plain enough that the poisonous products, of the tubercle bacillus at least, act as their own antidotes. It has long been known that the products of certain innocuous microörganisms that normally exist in the intestines destroy the activity of the microörganisms and thus limit the processes by which they are generated.

These reflections in regard to the probable mechanism of the action of the curative lymph in tuberculosis are a logical outcome of views which I have for some time entertained concerning the natural history of typhoid fever.

Typhoid fever is a perfect example of a self-limited disease. I have many times watched the progress of this malady under absolutely no medicinal treatment, in mild cases in which no treatment was called for. In simple cases, in which the origin can be distinctly traced to the taking of the typhoid bacillus in drinking-water, a period of incubation of two to fourteen days is noted. At the end of this time the bacilli have fixed themselves in certain structures in the lower part of the small intestine and begin to produce a poison, in the form of a ptomaine, which has been isolated and described under the name of "typhotoxin." This poison finds its way into the blood and produces the elevation of temperature which characterizes the fever. The fever, high pulse, headache and other symptoms constitute what may be termed the reaction of the poison. The bacillus is not found in the general circulation and there is no reason to suppose that it is directly poisonous. The fever continues for about sixteen days, and then spontaneously subsides, presumably because the poison has exhausted itself or has been eliminated. During the stage of fever the intestinal glands in which the bacilli are lodged have first been swollen and inflamed and then necrotic; and then the dead parts are thrown off leaving simple ulcerations. The ulcerations finally heal and the disease has run its course; but during its progress the intestines throw off typhoid bacilli and these are capable of communicating the malady to other persons. In cases of typhoid fever it is probable that the typhoid ptomaine dislodges the typhoid bacillus and that it is competent to do this completely because the extent of the structures in which the bacilli are lodged and multiplied is limited.

A comparison of the natural course of typhoid fever with the process of cure of lupus, as described by Koch, shows many points of resemblance. The lupus extends because the tissue in which the tubercle bacilli are developed is not sharply limited as in the case of the intestinal glands. The poison generated by the tubercle bacilli in lupus usually is not taken in quantity into the blood, and there is seldom any considerable elevation of body-heat, or reaction, such as occurs in pulmonary tuberculosis. Heretofore the disease frequently has been cured by re-

moving the diseased tissues or by destroying the bacilli by external applications. I have already described the processes observed in the cure of lupus by Koch's lymph. Following the injection there is a strong constitutional reaction, and the affected parts apparently become inflamed, as do the affected parts in the early stages of typhoid fever. The diseased tissue then becomes "brownish and necrotic." This also occurs in typhoid fever. The necrotic tissue is then thrown off, leaving a healthy ulcer which promptly heals. The same process takes place in typhoid fever.

I can not resist the conviction that the idea in the mind of Koch which led to the discovery of the curative lymph was that a toxic bacillus is capable of producing a poison which would possibly destroy the bacillus, or at least would limit its activity and dislodge it from the system. Probably the curative and active agent in the lymph was obtained from tubercle bacilli and produced by them. It is now said that Koch regards his studies in tuberculosis as complete, awaiting only the results of experience in regard to the permanency of the cure and its application to advanced cases of disease. It is also said that Koch is extending his experiments and is endeavoring to find cures for typhus and typhoid, scarlet fever, measles and diphtheria. It may be that his line of research will be in the direction of finding a special poison, produced by microörganisms peculiar to each infectious disease, which will act on these microörganisms and the diseased parts as the curative lymph has been found to act on tubercle bacilli and tuberculous tissue. If this is the case I may hazard another speculation, which, it is to be hoped, will soon be realized, as were the predictions made in December, 1888.

It is possible, in the light of what has recently been accomplished by Koch, that in the near future many curative lymphs will be discovered, each produced by the special microörganism of a particular disease. It will then be not too much to expect that these agents will promptly arrest the different diseases to which they are applicable. For example, the typhoid lymph, the diphtheritic lymph, the lymph for measles, for scarlet fever, and so on, will promptly arrest these diseases and save patients from the

degenerations and the accidents that are liable to occur when morbid processes are allowed to run their course; and convalescence will be prompt, because the diseases will not have produced damage which can be repaired only by time. Truly, this would be a revolution in medicine, and it seems to be now impending.

LVI

LATE THEORIES CONCERNING FEVER

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In the human body and in the warm-blooded animals generally, there is a certain temperature, fixed within quite restricted limits, which is constantly maintained in health. In man the temperature of the blood is between 98° and 100° Fahr. The temperature under the tongue and in the armpits is about 98.5°, with a normal range of variation of about 0.5° below and 1.5° above. The hibernating animals present a very considerable depression in temperature during their winter sleep; but with this exception, the general temperature of the body in warm-blooded animals can not remain depressed for any considerable length of time without death. The human organism can not resist a continuous internal temperature of 104° for more than a few days; and it is true, as a rule to which there are few exceptions, that an internal temperature of 108.5° is fatal.

Within the body there is an oxidation of matter which produces heat; the animal temperature is moderated by loss of heat from the general surface and the lungs; and finally, the balance between the production and the loss of heat is regulated by the nervous system. When this balance is so disturbed that the heat-production is in excess of the loss, there is an elevation of temperature, and this is known as fever. It is the mechanism for the regulation of the heat of the body that is disturbed in prolonged exposure to external heat, as in sunstroke, in which there is no excessive production of heat in the organism. This is quite different from what is ordinarily known as fever, the high temperature being produced by external causes only.

Aside from the so-called thermal fever, ordinarily

known as sunstroke, physicians have recognized two varieties; one due to some toxic agent and known as an essential fever, and the other called symptomatic fever, being secondary to some extensive local inflammation. That there is a difference between these two conditions in many instances there can be no doubt; but this difference in many cases is not so sharply defined as was once supposed, for it is almost certain that agents producing fever are developed in inflamed parts and carried over the system by the blood. In true symptomatic fever, however, the local inflammation is primary and due, perhaps, to an injury; while in an essential fever the fever is primary, and whatever local inflammations are developed are secondary, or consecutive.

It may be assumed that all the essential fevers are produced by microörganisms. In typhoid, which may be taken as the type of the essential fevers, this organism is called the typhoid bacillus. It is thought that this bacillus is introduced into the body, frequently in infected water, and that it produces a poisonous substance, called a ptomaine, which is the immediate cause of the fever with its attendant phenomena. Precisely how the elevation of temperature is produced by this poisonous agent is not understood; but of the fact there can be no doubt.

Typhoid fever belongs to the class of self-limited diseases. It runs its course in a certain number of days, when the poisonous agent disappears and leaves the system to recuperate from the shock it has sustained. Restricting the term fever to the increase in the temperature of the body, a question of the first importance to determine is that of the mechanism by which this increase in temperature is produced. A study of this question has contributed more than anything else to a system of rational treatment.

It can hardly be doubted that excessive heat-production is an element invariably present in the essential fevers. The excess of heat involves excessive oxidation. Disturbances in the processes of digestion prevent an adequate supply of matter from without to meet this excessive oxidation; and of necessity the body itself is consumed and there is loss of weight. An important factor also in the production of the fever is disturbance in the

processes by which the heat of the body is moderated. While the mechanism of the fever involves an abnormal production of heat, which can not be prevented, either there is no increased activity in the cooling processes, notably evaporation from the skin, or the cutaneous transpiration is diminished. It is not probable that there is a primary disorder of the nerve-centres which regulate the animal temperature, although these may be secondarily affected. The poison in the blood induces excessive heat-production, and this continues until the poison is eliminated or destroyed. The poison disappears after a certain time in typhoid fever as in all self-limited diseases; but there are no means known to physicians by which this can be promoted or the effects with certainty counteracted, as in the case of antidotes to mineral and other poisons. As a rule, in typhoid fever the toxic agent produces certain effects which continue for a limited time. The secondary effects of the fever-producing cause may be counteracted or moderated, but the elimination of the cause by measures of treatment has not been as yet effected. Nevertheless, it is not to be supposed that this will be impossible in the future of medical science.

It is interesting to contrast the picture of a typhoid fever patient with that of a person who is normally producing an excessive quantity of heat. In the case of fever the undue production of heat continues and is beyond the control of the physician. The patient is lying in his bed, doing no work, incapable for the time of doing work, and yet processes go on which are consuming his body in the production of this excess of heat and his tissues in a measure are passing away. Those parts of the tissues, indeed, which remain are undergoing degeneration. The excess of heat can not be converted into force, and the tissues suffer because an adequate supply of fuel in the form of food is impossible. The safety valve of the skin, which normally moderates the body-temperature, is closed. Experiments have shown that the passage of heated blood through the heart is largely responsible for the rapid action which is characteristic of fever, and it is more than probable that the hot blood circulating in the substance of the heart itself produces those degenerations which lead to so-called heart-failure.

In contrast with this diseased condition is the picture of a man producing an excess of heat by vigorous muscular work. Here there is increased oxidation and an excess of heat produced; but a large part of this excess is converted into force, and there is increased action of the skin, which keeps the heat of the body within restricted limits. The matter consumed is supplied by food, and the body itself is not wasted, or if in part consumed, is promptly repaired. While the actual heat of the body may be raised, this is but temporary and does no harm. In very violent exercise, as in fast running, the increased production of heat may be so rapid that it can not be entirely compensated by evaporation from the skin, and the temperature has been known under these conditions to rise to 104°, which is a high temperature for typhoid fever; but in the course of a little more than an hour it falls to the normal standard.

In health, when the body is subjected to excessive cold, the normal temperature is maintained, not only by retarding the radiation of heat from the surface by appropriate clothing, but by an actual increase in the production of heat. This is promoted by muscular exercise, and the material necessarily consumed is supplied by what, under ordinary conditions, would be an excessive assimilation of food, particularly of fatty matters, which have a high heat-value when oxidized.

Most important of all considerations are the applications of the prevailing views of the cause and nature of fever to its treatment. Beginning with the normal processes involved in the production of animal heat, it may be stated succinctly that a certain number of heat-units are produced, chiefly by oxidation, and that the matter thus oxidized is supplied by food. The temperature of the body is kept at the normal standard by regulation of heat-dissipation, chiefly by the skin.

Restricting the consideration to typhoid, a toxic agent, probably the product of a special microbe, sets up an excessive production of heat, attended with impaired compensating action of the skin and serious trouble in digestion and assimilation. The life of this toxic agent is restricted within certain limits. The objects of treatment are to prevent death and to secure and promote

speedy and complete convalescence. Death may occur from the exhausting effects of a prolonged high temperature or from certain accidents immediately or indirectly due to the same cause.

In a great majority of cases of typhoid fever, if not in all, the typhoid bacillus finds its way into the system through the alimentary canal. The fact of its introduction can be definitely ascertained only after the diagnostic features of the fever have presented themselves in an unmistakable form. However, there are few physicians who have kept pace with modern clinical investigations who have not occasionally observed the good effects of thorough disinfection of the intestines early in typhoid. Even admitting that the disease can not be arrested in this way, in some cases it runs a short and mild course. Theoretically it may be assumed that it is possible to destroy a certain number of the microbes in the intestines before they have had time to find their way into the general system.

Assuming that the typhoid poison, once in the system, must run its course, that the fever can not be aborted, and that the general effects are due, directly or indirectly, to a prolonged high temperature, a rational measure of treatment is to reduce temperature and to keep it within certain limits, if it can not be brought to the normal standard. This question is the all-absorbing one of the present day in the treatment of the essential fevers.

There are certain agents, called antipyretics, which, administered internally, will reduce the temperature of the body and these have been largely used in fever. In most instances, in some way which is not exactly understood, they reduce the temperature in fever. The immediate effects of antipyrin or antifebrin, which are agents recently discovered, are so prompt and decided that there can be no doubt of their specific influence, whatever may be the mechanism of their action. The only questions in regard to their use have been whether or not they reduce the percentage of mortality, prevent the so-called accidents that sometimes occur in fevers, and promote rapid and thorough convalescence. These questions can not be regarded as definitely settled in the minds of all physicians. Certain it is that the statistical arguments in favor of their

use are not so convincing as those which relate to other measures directed against the single condition of increased heat of the body.

Theoretically, a rational mode of restoring the equilibrium between heat-production and heat-dissipation is to abstract the excesive heat of fever from the body. It is in this way that the normal temperature is maintained in health, when the internal calorific processes produce an excess of heat, part of which is converted into muscular force and part is dissipated by external radiation. When the body is exposed to prolonged and excessive external cold, this being the fixed condition, life is preserved by an increased internal production of heat. In fever the conditions are exactly reversed. An excessive internal production of heat may be assumed to be the fixed condition. This, if prolonged, produces profound and serious effects upon the circulation, digestion and nervous system and may threaten life. In a majority of cases the persistence of increased temperature is largely due to diminished heat-dissipation. One may well ask whether it is not better to attempt to reduce temperature by the abstraction of heat than by the use of internal antipyretics, the action of which is more or less uncertain. The danger-point in typhoid fever is almost universally admitted to be at about 103°. In very violent exercise in health, the temperature may even exceed this, but it is rapidly reduced by heat-dissipation.

The most rapid and certain way of abstracting heat from the body is by the cold bath. Within a few years baths have been extensively used in the treatment of typhoid fever. This measure is by no means new. In 1777 Dr. William Wright, who afterward became president of the College of Physicians, Edinburgh, was attacked with fever on shipboard. On the fifth day he caused himself to be douched with cold salt-water and continued this repeatedly for several days with the happiest results. A few years later (1787–'92) the celebrated Dr. Currie employed the cold bath in 153 recorded cases of fever. Recent statistics are very striking in their results. In 2,150 cases of typhoid fever, collected from various sources, by Brand, which were treated with "strict cold baths" before the fifth day, there did not occur a single death. In 18,612

cases under different methods of treatment, collected by Murchison, the rate of mortality was 18.62 per cent. The revival of the treatment of typhoid fever by the cold bath dates from a publication by Dr. Brand in 1861. The routine of this treatment is to immerse the patient in a bath at a temperature of 60° Fahr. for fifteen minutes every three hours, so long as his temperature is as high as 103°. It is, of course, essential that patients be placed in the bath and removed from the bath to the bed with the least fatigue possible.

On rational grounds, sustaining measures are important in the treatment of fever. About forty years ago, Dr. Graves, of Dublin, who afterward "fed fevers," was advised by a "shrewd country physician" never to let his patients die of starvation. A man at work makes more heat than in repose and needs more food. In a case of fever, although the patient does no work, he makes an excessive quantity of heat, and this involves of necessity oxidation of matter. If this matter is not supplied by food or some oxidizable material, the tissues must be consumed. Precisely in so far as the fever feeds on food, the tissues are saved and convalescence is promoted after the disease has run its course; but the condition of the organs of digestion and assimilation renders the introduction of food a problem requiring the greatest judgment and skill on the part of the physician.

The question of the administration of alcohol in fever is one that can not be avoided. In my judgment this question should be discussed from a scientific standpoint only. In the face of the difficulty which exists in supplying matter for oxidation in the body to feed the exaggerated calorific processes, the use of any agent that will meet this want can not logically be condemned on sentimental grounds alone. Even if alcohol be regarded as a poison, it must be remembered that poisons are often useful in medicine and save life. From a purely scientific point of view, it may be admitted that in perfect health alcohol is not useful and is deleterious. As physicians study the poisonous action of certain remedies in learning how to use them with happy effect, so what may be called the physiological effect of alcohol may be studied as a preparation for its use in disease.

The symptoms of alcoholic intoxication are due to certain peculiar effects on the nerve-centres of actual alcohol circulating in the blood. In perfect health a very small quantity of alcohol will produce some effect of this kind; but this passes away when the alcohol is eliminated by the breath or otherwise or when it is oxidized. In certain diseases, particularly in fever, it is well known that very large quantities are tolerated, and this is because the alcohol is promptly oxidized and makes no impression, as alcohol, on the nervous system. In disease, as well as in health, even a slight development of alcoholic intoxication is followed by a reaction which is more or less injurious.

Alcohol is not to be used indiscriminately in fevers. It is indicated only when there is a persistence of very high temperature, with great feebleness, rapid pulse, etc., showing great general depression. Its value depends, not on its stimulating effects on the nervous system, but on its rapid oxidation. It is promptly taken up by the blood, requires no preparation by digestion and is oxidized even more readily in fever than in health. In so far as it is oxidized it supplies material for combustion and saves the tissues from degeneration and destruction. There is a theory that the carbohydrates of food (starches and sugars) are deposited in the liver, discharged into the blood as required in the form of a substance called glycogen which is converted into alcohol and then oxidized. There are many facts and arguments in favor of this view; and if true, the administration of alcohol in fever is simply the introduction of the product of a carbohydrate in such a form that it can be promptly used in supplying material for heat, the digestion of unchanged carbohydrates being difficult and slow. A calculation of the heat-value of alcohol shows that one quart of French brandy when oxidized produces as many heat-units as a man of ordinary size would make in twenty-four hours. As a matter of actual observation, a quart or even more of brandy has been given in cases of fever in twenty-four hours, without any indications of alcoholic intoxication, and with the effect of reducing temperature.

The popular interest in the question of alcohol seems to render it desirable that the position of physicians who use this agent in disease should be clearly defined. Taking

fever as an example, physicians give alcohol simply as a readily oxidizable substance, and not for what is commonly known as an alcoholic stimulant effect. Although in certain cases it may be given very largely, it is stopped or the dose is diminished whenever the slightest indication of alcoholic intoxication appears. It would be difficult to find an instance of the alcoholic habit directly referable to the use of alcohol in fever; and, indeed, so far as habit is concerned, it would be much more logical to condemn opium than alcohol. No physician would be willing to eliminate opium from his materia medica. Those who refuse to administer alcohol under any circumstances deprive themselves of an agent that is often most potent for good, and must occasionally sacrifice life to what the majority of intelligent physicians regard as a prejudice.

It would be out of place to give or to attempt to give in this article a full account of the pathology and treatment of fever; but it is hoped that many are interested in a general way to know the grounds on which the practical ideas of physicians are based. In contrasting the medicine of a half-century ago with the medicine of to-day, it is easy to see how imperfect knowledge leads to errors in practice. The immense advances, however, within the last fifty years, especially the discovery of the disease-producing microbes, lead one to speculate on the possibilities of the future, as I did in an article entitled "A Possible Revolution in Medicine." Revolutions in any branch of science, while they may receive a great impetus from a single remarkable discovery, are constantly and slowly progressing with the gradual accumulation of experience such as occurs in the science of medicine, particularly in hospital practice. The example of 2,150 fever patients, under a certain plan of treatment inaugurated before the fifth day, without a single death, may come home to some who read this article. The results of such experience will show why the most eminent members of the medical profession are not only willing but anxious to serve in hospitals without fee or reward. It is not too much to say that a patient in a pauper hospital has a better chance of recovery than many whose condition in life commands everything in the way of care and attention. One can hardly realize how much the poor in hospitals contribute to the health and

happiness of those by whom the hospitals are sustained. Fortunately, hospital methods are being rapidly introduced into private practice; and this has been rendered possible by the substitution of the intelligent trained nurse for the traditional Mrs. Gamp and Mrs. Harris.

LVII

THE EYE AS AN OPTICAL INSTRUMENT

Published in "The Popular Science Monthly" for June, 1894.

I HAVE often wondered whether the statement, sometimes made by physicists, that the human eye is not a perfect optical instrument, is an expression of human vanity or of an imperfect knowledge of the anatomy of the eye and the physiology of vision; and I have come to the conclusion that the latter is the more reasonable theory. The approach to perfection in modern telescopes and microscopes is wonderful indeed; but as physiologists have advanced the knowledge of vision, the so-called imperfections of the eye have been steadily disappearing; and even now there is much to learn. Viewed merely as an optical instrument, an apparatus contained in a globe less than an inch in diameter, in which is produced an image practically perfect in form and color, which can be accurately adjusted almost instantly for every distance from five inches to infinity, is movable in every direction, has an area for the detection of the most minute details and at the same time a sufficient appreciation of large objects, is double, but the images in either eye exactly coinciding, enables us to see all shades of color, estimate distance, solidity, and to some extent the consistence of objects, the normal human eye may well be called perfect. The more, indeed, that the eye is studied in detail, the more thoroughly does one appreciate its perfection as an optical apparatus.

Were it not for a slight projection of the cornea (the transparent covering in front) the eye would have nearly the form of a perfect sphere a small fraction less than an inch in diameter. It lies in a soft bed of fat and is held in place by little muscles and a ligament which is so lubricated that its movements take place with the minimum of friction. It is protected by an overhanging bony arch and

the eyelids, the eyelashes keeping away dust and the eyebrows directing away the sweat. Situated thus in the orbit, the eyes may be moved to the extent of about forty-five degrees; but beyond this it is necessary to move the head.

The accuracy of vision depends primarily on the formation of a perfect image upon the retina, which is a membrane sensitive to light and connected with the optic nerve. That such an image is actually formed has been demon-

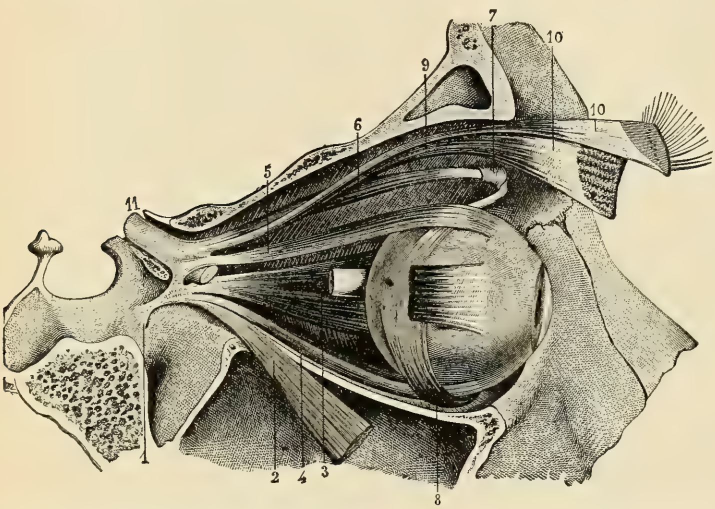

Fig. 1.—This figure gives a general view of the eyeball, the outer wall of the orbit being removed: *1*, tendon of origin of three of the muscles of the eyeball; *2*, the external straight muscle divided and turned down so as to expose the lower straight muscle; *3*, *4*, *5*, *6*, *7*, *8*, muscles moving the eyeball; *9*, *10*, *10*, muscle which raises the upper eyelid; *11*, optic nerve. (After Sappey.)

strated by the ophthalmoscope, which enables us to look into the eye and see the image itself. Although the image is inverted, the brain takes no cognizance of this, and every object is appreciated in its actual position. The image is formed in the eye in the way in which an image is produced and thrown on a screen by a magic lantern.

When a ray of light passes obliquely from the air through glass, water or other transparent media, it is bent, or refracted, and the angle at which it is bent is called

the index of refraction. In passing to the retina, the rays of light pass through the cornea, a watery liquid (the aqueous humor) surrounding the lens, the crystalline lens, and a gelatinous liquid (the vitreous humor) filling the posterior two-thirds of the globe, all of which have nearly the same index of refraction. This provides that a ray of light, having once passed through the cornea, is not refracted in passing through the other transparent media, except by the curvatures of the crystalline, which is a

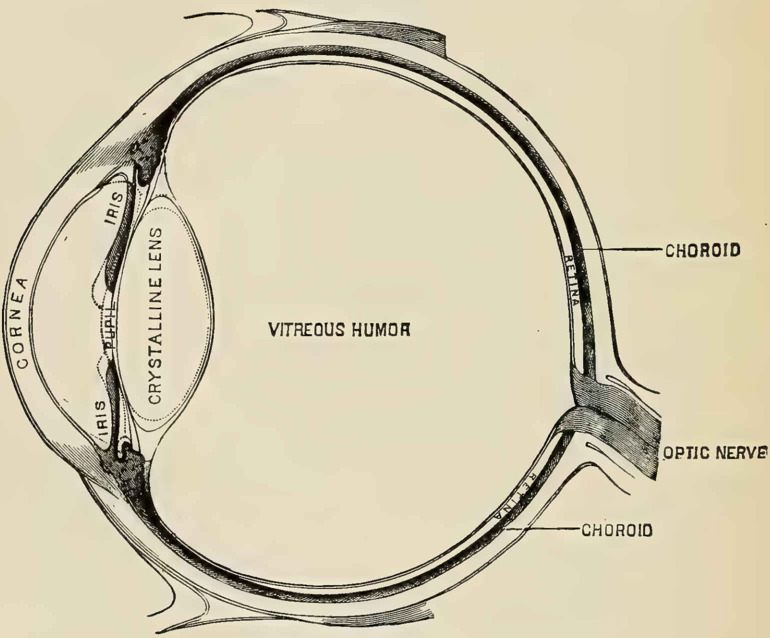

FIG. 2.—Diagrammatic section of the human eye.

double-convex lens situated just behind the pupil. The rays of light are not reflected within the eye itself, for the opaque parts of the globe are lined with a black membrane (the choroid), as the tube of a microscope is blackened for a similar purpose. Practically, the bending of the rays of light is produced by the curved surface of the cornea and the two curved surfaces of the double-convex crystalline lens. These three curved surfaces bring the rays from an object to a focus exactly at the retina in a normal eye.

When, however, the eye is too long, the focus is in front of the retina unless, in near vision, the object is brought very near the eye; and the person is near-sighted. For ordinary vision, such persons must wear properly adjusted concave glasses to carry the focus farther back. When the eye is too short, the focus is behind the retina; and the person is far-sighted and must wear convex glasses. The first condition is called myopia, and the second, hypermetropia; but in most persons who are obliged to wear convex glasses in advanced life, the crystalline lens has become flattened and inelastic, the diameters of the eye being unchanged. This condition is called presbyopia, which means a defect in vision due to old age.

What is called the area of distinct vision is a depression in the yellow spot of the retina, which is probably not more than a thirty-sixth of an inch in diameter. It is with this little spot that we examine minute details of objects. If we receive the rays of light from an object on a double-convex lens and throw them on a screen in a darkened room, the image of the object appears on the screen; but in order to render this image even moderately distinct it is necessary to carefully adjust the lens, or the combination of lenses, to a certain distance, which is different for lenses of different curvatures. In the human eye the adjustment is accurately made, almost instantaneously, for any desired distance, not by changing the distance between the crystalline lens and the retina, but by changing the curvature of the crystalline lens itself. The way in which this is done has been known only within the last few years. The lens is elastic, and in a quiescent, or what is called an indolent condition, is compressed between the two layers of the ligament which holds it in place. In this condition, when the rays from distant objects are practically parallel as they strike the eye, the lens is adjusted for infinite distance. When, however, we examine a near object, by the action of a little muscle within the eyeball the ligament is relaxed and the elastic lens becomes more convex. This action is called accommodation, and is voluntary, though usually automatic. The fact that it is voluntary is illustrated by the very simple experiment of looking at a distant object through a gauze placed a few feet from the eye. When we see the distant object distinctly, we do not

see the gauze; but by an effort we can distinctly see the meshes of the gauze, and then the object becomes indistinct. In some old persons the lens not only becomes flattened, but it loses a great part of its elasticity and the power of accommodation is nearly lost.

The changes in the curvatures of the lens in accommodation have been actually measured. The lens itself is

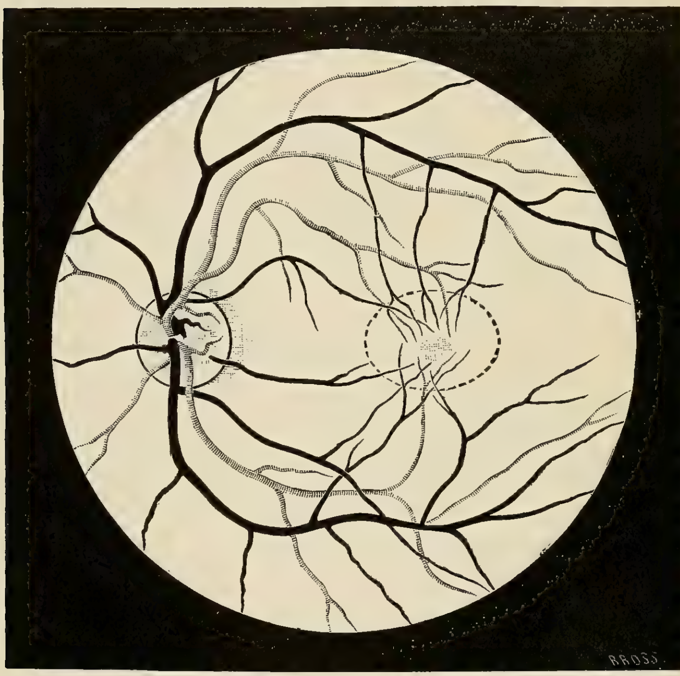

FIG. 3.—Visual portion of the retina as seen with the ophthalmoscope; magnified about seven and a half diameters, showing the blood-vessels branching from the point of entrance of the optic nerve, and the yellow spot surrounded by the dotted oval. (After Loring.)

only about a third of an inch in diameter and its central portion is only a fourth of an inch thick. Adjusted for infinite distance, the front curvature has a radius of about four-tenths of an inch, while for near objects the radius is only about three-tenths of an inch. A curious experiment is looking at a minute object through a pinhole in a bit of paper or cardboard, when the object appears highly

magnified. This is because the nearer the object is to the eye, the larger it appears. The shortest normal distance of distinct vision is about five inches; but in looking through a pinhole we can see at a distance of less than an inch, using a very small part of the central portion of the crystalline lens. Accommodation for very near objects is assisted, also, by contraction of a little band of fibres in the iris, about a fiftieth of an inch in width, immediately surrounding the pupil.

In grinding lenses for the microscope, it is mechanically easy to make a very small lens with perfectly regular curvatures; that is, each curvature being a portion of a perfect sphere; but in such a lens the focus of the central portion

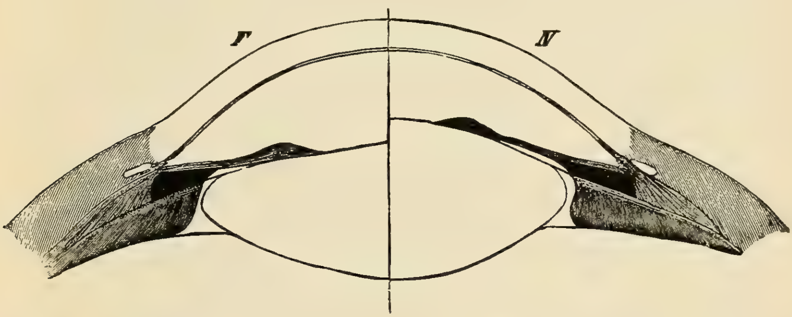

FIG. 4.—Section of the lens showing the mechanism of accommodation. The left side of the figure (*F*) shows the lens adapted to vision at infinite distances. The right side of the figure (*N*) shows the lens adapted to the vision of near objects. (After Fick.)

is longer than that of the parts near the edge; and when an object is in focus for the centre it is out of focus for the periphery. This is a fatal objection to the use of uncorrected lenses of high power; but in microscopes it is corrected by combinations of lenses, reducing the magnifying power about one-half. When white light passes through a simple lens it is decomposed into the colors of the spectrum. This is called dispersion, and it surrounds the object with a fringe of colors. The dispersion by concave lenses is exactly the opposite of the dispersion by convex lenses, so that this may be corrected by a combination of the two; but when this is done with lenses made of the same material, the magnifying power is lost. New-

ton supposed that it was an impossibility to construct a lens corrected for color, which would magnify objects; but since the discovery (in 1753 and 1757) of different kinds of glass having the same refractive power but widely different dispersive powers, perfect lenses have been possible.

In the human eye a practically perfect image, with no alteration in color, is produced by a mechanism which human ingenuity has not been able to imitate. There is a slight error in the cornea, which is corrected by an opposite error in the crystalline lens; the iris plays the part of the diaphragm of optical instruments and shuts off the light from the borders of the crystalline lens, where the error is greatest, particularly in near vision; the curvatures of the lens are not perfectly spherical, but are such that the form of objects is not distorted; and while such curvatures are theoretically calculable, their construction is practically impossible, as experience has shown; different layers of the crystalline lens have different dispersive powers; and thus an image, with no appreciable distortion or decomposition of white light, is formed on the retina.

FIG. 5.—Achromatic lens.

There is a division of the sensitive parts of the retina into a small area for distinct vision, which is used in reading, for example, and a large surrounding area in which vision is indistinct. If all parts of the retina were equally sensitive, vision of minute objects would be confused and imperfect. As it is, the area of distinct vision is very small, probably less than one thirty-sixth of an inch in diameter. In this area the distance between the separate sensitive elements is not more than one thirty-five-hundredth of an inch; while in passing from this only eight degrees, the distance is increased a hundred times. Still, while looking at an object in the line of distinct vision, indistinct images of surrounding objects are appreciated, warning us, perhaps, of the approach of danger.

The mechanism of distinct and indistinct vision has been understood only since 1876. The sensitive parts of the retina are little rods and cones forming a layer by themselves. In 1876 Boll discovered that in frogs kept

in the dark the rods of the retina were colored a dark purple; but on exposure to light the color faded, becoming first yellow and then white. Since that time physiologists have carefully investigated visual purple and visual yellow. Just outside the layer of rods and cones are the dark cells which render the greatest part of the interior of the eye almost black. In the dark these cells send little hair-like filaments between the rods and discharge a liquid which colors the rods only. When the rods are thus colored, the eye is extremely sensitive, so that a bright light is dazzling and painful and obscures distinct vision. This is the reason why we can not see distinctly coming suddenly from the dark into a full light. In a few seconds, however, the color is bleached to a yellow and the difficulty passes away. When, on the other hand, we pass from a bright light into the dark, the retina has lost its sensibility, and we can not see until the purple is reproduced, as it is in the absence of light. This difference is not due to dilatation of the pupil in the dark and contraction under the influence of light, as is popularly supposed, for a person does not see better in the dark when the pupil has been dilated by belladonna.

In the area for distinct vision there is never any visual purple. This area we always use with sufficient light for minute details of objects, making then the greatest use of the mechanism of accommodation. The area outside of this is used for indistinct vision; and as the color is then yellow instead of purple, it is only moderately sensitive. To express the conditions in a few words, the area for distinct vision is used by day, and the area for indistinct vision, with its visual purple, is used by night.

Sometimes, in long tropical voyages, sailors become affected with total blindness at night, while vision in the daytime is perfect. The glare of the sunlight in the day bleaches the visual purple so completely that it can not be restored in a single night, and the area for indistinct vision becomes insensible. This trouble is purely local and is remedied by rest of the eye. If one eye is protected by a bandage during the day, this eye will be restored sufficiently for the next night's watch, while the unprotected eye is as bad as ever. Snow-blindness is due to the same cause.

We receive normally the impression of a single object, although two images are formed, one in either eye; but it is necessary that the images be made upon corresponding points in the two retinas. If the angle of vision in one eye is deviated, even in a slight degree, by pressing on one globe with the finger, we see two images. One can appreciate how exactly these points must correspond when it is remembered that two rays of light appear as one only when the distance between them is one thirty-five-hundredth of an inch.

In each eye there is a "blind spot" at the point of penetration of the optic nerve; but inasmuch as this spot is in the area of indistinct vision, and is so situated—a little within the line of distinct vision—that an impression is never made on both blind spots by the same object, this blindness is not appreciated, and the spot can be detected only by careful investigation.

It is literally true that a person may see and not perceive. It has happened, in certain injuries of the brain, that a person sees and reads the words in a book and yet does not perceive their significance. This is called word-blindness. In a certain portion of the brain is a part which enables us to recognize the fact that we see an object; yet this object conveys no idea. There are two of these so-called centres of vision, one on either side, and their action is partly crossed. When the centre is destroyed on one side, the inner half of one eye and the outer half of the other eye are blinded. Farther back in the brain, however, is a centre which enables us to perceive or understand what is seen. When this centre is destroyed we see objects and may avoid obstacles in walking, but persons, words, etc., are not recognized. This centre exists only on the left side of the brain.

An impression, however short, made on the retina is perceived. The letters on a printed page are distinctly seen when illuminated by an electric spark, the duration of which is only forty-billionths of a second; but the impression remains much longer. Anything in motion appears to us in a way quite different from the single impression from an electric spark. In a picture representing an animal in motion, as it appears in an instantaneous photograph, the positions seem absurd and like nothing we

have ever seen. In looking at a horse in action, the impressions made by the different positions of the animal run into each other, and art should represent as nearly as possible the sum or average of these impressions. It is also true that impressions are diffused in the retina beyond the points on which they are directly received. This is called irradiation; and the impression is diffused farther for white or light-colored than for black or dark objects. It is well known that a white square looks considerably larger than a dark square of exactly the same size; or the hands in white gloves look larger than in black gloves.

There are many interesting facts in connection with vision which space has not permitted me to discuss; but there still remains much that is not yet understood. The mechanism of the appreciation of colors and color-blindness, for example, are still unexplained. It is well known that some persons can not distinguish between certain colors, but the reason of this is obscure. Perfect sight can exist only when the eye is perfect. The form and color of objects may be distorted so that an inaccurate image is formed upon the retina, and this image, however imperfect it may be, is what is perceived by the brain. In audition the case is different. The waves of sound, if they are conducted to the internal ear and if the nerve of hearing, with its terminations, is normal, can not be modified in course of transmission. Sounds are always appreciated at their exact value, except as regards intensity.

Enough has been said about the eye, I think, to show that it is perfectly adapted to all requirements; and whatever defects it may seem to have, viewed as an optical instrument, render it more useful than if these apparent imperfections did not exist.

LVIII

WHY MEN MUST DIE

Published in "The Youth's Companion" for September 27, 1894.

THE man who arrives at the age of one hundred years is regarded as an extraordinary being; and so he is; for he has escaped various accidents, he probably has lived a perfectly normal and temperate life and his intellectual faculties have not encroached upon his purely physical existence. Nevertheless, a hundred years is pretty well agreed upon by physiologists as the natural span of human life.

The experience of all time has shown that every living thing has a definite term of existence; and in living things are included vegetables as well as animals, everything, indeed, that we know to have a beginning, a growth and a maturity. The normal duration of life in the lower animals commonly is equal to five times the number of years required to reach the age of maturity. According to this law a man should live a hundred years. In the animal kingdom there are many exceptions to this; but it does not appear that man is one of these exceptions.

It is a question whether a life of a century contributes anything to human happiness or even to the happiness of the individual who may thus fill out the measure of physiological existence. Few have done anything for themselves or humanity much after the age of three score and ten. The brilliant exceptions did their greatest work before that age, no matter how well they did afterward; and those who have reached one hundred or more years have usually been celebrated for their age only.

The most thoroughly authenticated instance of a life prolonged much beyond the ordinary limits is the case of Thomas Parr, of Shropshire. He is said to have lived to the age of one hundred and fifty-two; and he did work as

a farm-laborer until he was one hundred and thirty. At the request of the king he went to London in his hundred and fifty-second year and was so liberally entertained at court that he died of a plethora, it is said, a few months later. After death his body was examined by Harvey, the discoverer of the circulation of the blood, who found all his internal organs in perfect condition.

Many persons have lived to the age of a hundred years; of this there can be no doubt. Assuming a hundred years to be about the limit of human life, how should an individual live in order to reach that age?

A man has the best chance of a long life if he does nothing which has a tendency to shorten it. His heart must circulate the blood and the vessels must carry the blood to every part. When the circulation ceases, death is inevitable unless the current of blood is promptly restored.

It is evident, therefore, that the heart should never be overworked to the extent of becoming permanently damaged; for this organ is required to contract about a hundred thousand times in a day, waking or sleeping, at work or at rest, and it can not, like an ordinary muscle, be allowed any time for repose when overfatigued or injured.

If the heart is to make three thousand six hundred and fifty million successive contractions without intermission or repose, it is not only entitled to, but it must have very considerate treatment. It weighs less than three-quarters of a pound; but it has more responsibility than the entire muscular system.

However, the heart is so guarded and protected, its work is so nicely regulated by the nervous system and any voluntary act calculated to do it serious damage is so difficult that it does its work from the beginning to the end of life without our consciousness. A small proportion, only, of natural deaths are directly due to failure of the heart.

All animal life calls for a constant supply of oxygen, which is obtained from the air. Without air the blood can not circulate; and without circulation there can be no digestion, no absorption, nutrition, power of motion, sensibility or volition, and life ceases in a few minutes. To take in air, we must make about twenty-five thousand

muscular efforts a day; but these, unless we voluntarily direct attention to them, go on without volition or consciousness. The movements of respiration are controlled and regulated by a collection of nerve cells situated at the base of the brain; and this part is seldom involved in disease. Even in extreme old age the capacity of taking air into the lungs is not materially diminished; and there is therefore no danger of death from want of breath.

It is not unusual to find very old persons with perfect digestion and with all the secretions in a normal condition. Some retain the perfection of sight and hearing to the end of a natural life and are capable of moderate exercise in extreme old age; yet all die, even though meeting with no fatal accident or becoming affected with what may properly be called disease.

If we know precisely why death is inevitable, we are in a good position to learn the means of prolonging life to its utmost limit. Man must die simply because he lives. Life implies constant change of matter in the body.

A globule, less than one-hundredth of an inch in diameter, is the beginning of life. As the seed planted in the ground, nourished by air, water and surrounding matters, grows and becomes a plant or a tree, so this little globule has in it the principle of life and under favorable conditions may become a man.

The oak may live for fifteen hundred years; and it has been calculated that the gigantic baobab of Africa has lived for five thousand years; still they have a limited existence, and their immortality is in the new trees produced from them, as man's immortality on earth is in his posterity.

The fact that life implies change makes death a logical necessity. For nearly twenty-five years the changes in the body include growth. After that the changes of wear and repair do not exactly balance each other, and a time is sure to come when it is evident that the body is wearing out.

Why is it that a man, a horse or any other animal is able to do less work after a certain age? It is simply because, while he must absorb a certain quantity of oxygen to keep up the heat of the body and to maintain circulation and the respiratory movements, the additional oxygen that can be used in work becomes less and less as

the body grows older. After a time he is able to do little or no work; and he can use barely enough oxygen to keep up the heat of the body, the beats of the heart and the movements of breathing.

This capacity of taking and using oxygen from the air is constantly diminishing; and the time must come when the vital powers fail to supply the force required for processes that are essential to life, and then the life of the individual comes to an end.

A mechanical apparatus, like a steam engine, produces a certain quantity of force, which is in proportion to the fuel consumed. When no fuel is consumed there is no force. If the parts of the steam engine are repaired or restored as they wear out, the force may go on so long as fuel is supplied. No part of the machinery is consumed, except by friction, as it is the fuel only that is destroyed.

The animal body is composed of living, or organic matter, which is capable of repairing itself by using the food taken, and of inert, or mineral and earthy matters. As age advances, the proportion of living matter diminishes and the inorganic matters are increased. Thus the body must become less and less capable of repairing the loss due to work; for as it works it consumes its own substance; and after a time it becomes useless, like a piece of machinery that is not repaired.

How can one so regulate his life as to live for a century?

In the first place, no one who inherits a tendency to disease can hope to reach an advanced age. If he is a dwarf or a giant, is excessively emaciated or inordinately fat, if he is deformed or weak in any vital organ, he can not expect to live as long as the average.

He must have the good fortune to escape accidents, including infectious and contagious diseases and diseases due to impure food or drink. His childhood and youth must be so directed that he arrives at his full development without injury and becomes a perfect man. This presupposes that he is well fed and nourished, that he has proper exercise for the development of every part and is never overworked, that he has never become even aware of the existence of a heart, a digestive apparatus, kidneys or liver, the internal organs working perfectly and uncon-

sciously. It must be that many arrive at the age of maturity under such conditions as these; but having developed into a perfect maturity, what is not to be done and what is to be done to prolong life to its extreme limit?

Avoid all impurities of air, exposure to extremes of heat and cold, excessive fatigue, strong emotions of any kind, all stimulating, highly-seasoned or indigestible food, all drinks containing alcohol, sedatives, such as tobacco, even the mildest nerve stimulants, such as tea and coffee, intellectual effort when it produces the slightest sensation of fatigue, everything that is likely to produce anxiety or worry, all enterprise and ambition, as likely to lead to disappointment and regret, and all acts of charity or good to others that involve the slightest personal discomfort or sacrifice. In short, avoid everything that disturbs the routine of a perfectly normal physical existence and everything in civilization that tends to render physical life artificial.

What not to do implies, to a certain extent, what one is to do. Live in the country, where all surroundings are pure and wholesome. Rise and retire with the sun, on the principle that more sleep is required in winter than in summer. Eat three times a day of food prepared in the plainest manner, using only salt as a condiment, on the principle that a little more salt than is contained in ordinary food is necessary for proper nutrition and is craved by all animals.

The conformation of the teeth and of the digestive organs shows that man is an omnivorous animal; therefore, eat both of meats and vegetables, but of meat once a day only. Stop eating when hunger is satisfied, and stop drinking when no longer thirsty, of course never allowing the appetite to be tempted by peculiarly agreeable articles of food after hunger has been satisfied. Have food present a certain variety. Experience has shown that this is conducive to health.

Take moderate exercise at times when digestion is not going on, so as not to become too fat. Marry at about the age of twenty-five years, the time of perfection of physical life; for man, like some of the inferior animals, is monogamous.

Here, perhaps, is the greatest risk for one whose sole

aim is to prolong his own life. If one can marry and have no anxieties or care for his wife and children, be exposed to no afflictions or excessive emotions and have the life of his family entirely subservient to his own, marriage will probably be favorable to longevity. But experience has shown that these conditions are not often realized.

In short, to reach extreme age one should live a perfectly selfish life, with but one end in view, doing no good to others and doing no evil, but still always selfish.

A classical writer on the "Art of prolonging Life" said, a hundred years ago, that "Almost all those kinds of death which take place before the hundredth year are brought on artificially,—that is to say, by disease or accident,—and it is certain that the far greater part of men die an unnatural death, and that not above one in a thousand attains to the age of a hundred years."

The writer referred to died at the age of seventy-four; but he was a distinguished and laborious physician and philosopher.

I do not imagine that any reader of this article will try to live a hundred years. The chances of success are too small to induce any reasonable being to begin a life, at the age of twenty or twenty-five, of absolute devotion to the physical self the only prospective reward being to exist until it becomes only too evident that "superfluous lags the veteran on the stage."

Far better is it to live a rational, virtuous and useful life, with reasonable ambitions and aspirations, enjoying in moderation the good things Nature and civilization have provided and doing one's share of work for the good and happiness of mankind.

LIX

THE COMING RÔLE OF THE MEDICAL PROFESSION IN THE SCIENTIFIC TREATMENT OF CRIME AND CRIMINALS*

Published in the Transactions of the New York State Medical Association for 1895.

DR. CESARE LOMBROSO, in his work on "The Applications of Criminal Anthropology," quotes Rondeau as saying, in an essay on the death penalty:

> "Even assassins are patients, as well as all other criminals. They should be punished because they disturb the regular course of social life, because they are obstacles to the development of the species.
>
> "Conceding that every crime is the natural outcome and a logical consequence of some disease, its penalty should be nothing else than a medical treatment."

The idea which underlies the view of Rondeau is that moral liberty has no existence and that a moral evil is the result of physical fault. "In his system of repression all prisons would be transformed into hospitals; no attempt would be made to improve the organization of convicts. The thief and the vagabond would be treated by making them taste the joys of work, and in secluding for life those inaccessible to all treatment."

Society, I venture to say, is hardly prepared to accept the logical consequences of these views; but it must be admitted that the treatment of crime and criminals under existing laws and their methods of execution is a failure, and a failure so serious in its results that it is difficult to imagine what will occur before a revolution takes place and scientific criminology and penology become established as part of the social fabric.

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* President's annual address, October 16, 1895.

It has been stated on competent authority that crime in Great Britain is responsible for an annual public expenditure of ten millions of pounds sterling. "According to a recent report to the Ohio Board of State Charities, the citizens of the United States spend an annual sum of fifty-nine million dollars on judiciary, police, prisons and reformatories." The president of the National Prison Congress of the United States says:

"Other questions which agitate the public and divide parties are doubtless important; but the country can live and prosper under free trade and protection, under bimetallism or monometallism, under Democracy or Republicanism, but it can not survive a demoralized people with crime in the ascendant. That crime is on the increase out of proportion to the population is indicated in many ways, but for the country as a whole the United States census is the most reliable guide. Let us look at it by decades:

	Prisoners.	Ratio to population.
1850	6,737	1 in 3,442
1860	19,086	1 in 1,647
1870	32,901	1 in 1,171
1880	58,609	1 in 855
1890	82,329	1 in 757

"In Great Britain, Germany, France, Italy and other civilized countries, the penal systems do not differ very materially from ours; and we may assume that in these countries crime is not more successfully treated. What wonder is it, then, that jurists who have studied this great question, like von Liszt, of Germany, 'admit that our existing penal systems are powerless against crime'!"

The chief object of a penal system is the protection of society. The facts that I have just cited show that the protection of society against crime and criminals is becoming more and more alarmingly inefficient.

The statements and statistics just given have not been exhumed from obscure sources. They are taken from Morrison's introduction to "The Female Offender," by Lombroso and Ferrero, recently republished in New York and extensively circulated. Without considering the merits of this book in the form of its mutilated and imperfect translation, the statistics alone, given in the introduction, should awaken the public to the necessity of reform in penal methods and the danger of delay.

Sentimentality in questions of criminology and penology should be put aside. It has no more place in criminal law and penal administration than in medicine or surgery.

Crime is a disease of our social organization. It is true that it is ineradicable, but it may be restricted within much narrower limits than at present exist. Crime calls for intelligent and scientific treatment. While crime can not be abolished, all criminals are not hopelessly affected with crime. Individuals may be protected against crime as Jenner has protected individuals against small-pox. Crime may be a constitutional disease, as in the born criminal, or it may be due in individual cases to surroundings, teaching or example—a sort of contagion. It has been shown that criminals may be divided into two great classes, the curable and the incurable; but the disease which is called crime has nearly as many phases and varieties as are to be found in the nosological catalogue. Society needs the aid of competent men to undertake the task of separating the curable from the incurable, to restore the former to usefulness and to protect our social organization against the latter. Jurists, so-called law-givers and those who execute the laws have failed. In my opinion the only hope is in the medical profession. This is the explanation I have to give of bringing the subject of crime before the "Association." I have lately become fully sensible of the extent and importance of the subject in its relations to the profession, and more than all, of my deficiencies in study and experience in the questions involved; but no problem can come before us more worthy of thorough investigation and careful consideration. I venture to recommend and hope that in a future meeting the Association may make this matter the subject of formal discussion and attempt to devise something to meet in a measure the existing and pressing necessity for reform.

It is to be feared that the medical profession can have little direct influence in the making or repeal of laws. The past does not show any encouraging success in this direction. The protection of the community against so dangerous and evident an evil as the unrestricted sale of patent medicines of unknown composition, many containing powerful and deleterious drugs, has never been accomplished. The profession has found itself powerless against the pecuniary interests involved in the sale of secret remedies, and has not been able, even, to compel the disclosure of the composition of these preparations so that the public

might know what it is buying. How little, then, can we hope to do in the way of enacting intelligent penal laws or of repealing bad laws that have been handed down from antiquity! Our chief hope at present is to induce judges, lawyers and lawmakers to study criminal law in the light of modern scientific knowledge.

The existing system of criminal law is based on the ancient idea of vengeance and retaliation in the form of what is known as punishment. Crimes that are not criminal and offenses that do not offend are created every year by legislative bodies, as well as laws which restrict the liberty of certain classes, giving special privileges to others. Police organizations, whose duty it is to preserve rights, order, cleanliness, health, etc., and who are "for the enforcement of the laws and the prevention of crime," often induce, by fraud and deceit, men to commit so-called crimes so that they may be punished therefor. Does not this tend to add to the number of enemies of society, already so numerous and threatening! Are the real offenses against good order and the happiness of the people so easily repressed that we can afford to create new and artificial crimes by statute!

In its application to the treatment of crime and criminals, the idea of the word law, in the minds of jurists and legislators, needs revision. In its strict and scientific sense, the word law means something that is laid, fixed or set. A law is something that exists, has existed from the beginning, and the mind of man can not conceive that it will ever cease to exist. Man can neither make, destroy nor modify a law any more than he can create or annihilate an atom of matter. Laws, when known, have been discovered by man, not created. The laws of gravitation, of the correlation and conservation of forces, of certain diseases, and, the most terrible of all, the law of heredity and atavism, have been discovered by scientific searchers after truth. Man may modify the working of certain natural laws; but the laws themselves remain fixed and immutable. The universe, animate and inanimate, including man, exists and progresses in accordance with laws, known and unknown. Man is subject to psychical as well as physical laws; and no human act is without a cause, immediate or remote. In a so-called legal sense and in

its relations to social organization, law may be termed formulated equity and applied justice; but in the words of Blackstone, " No human laws are of any validity if contrary to the law of Nature, and such of them as are valid derive all their force and all their authority, mediately or immediately, from this original."

Man is a gregarious animal. An outcome of the development of intelligence and knowledge, is social organization. This is in accordance with a law of Nature; and it involves the necessity of ordinances and regulations for the protection and preservation of communities. When these ordinances and regulations are inequitable and unjust, there is immediate dissatisfaction, and rebellion sooner or later. When the natural laws of what may be called man's physical organization have been violated, either in the individual or in his ancestry, the result is disease. A man may suffer for the faults of his own organism, or from infection or from contagion. It is the province of the physician to endeavor to cure the disease of an individual or care for him during its progress, so that he may be restored to health, and to protect individuals and communities against infection and contagion, thus preventing disease. Physicians have learned how to cure certain diseases; by the applications of sanitary science and quarantine they protect communities against certain diseases; recent discoveries have enabled them to secure immunity from certain diseases. In the future, carrying out recent researches in psychological medicine, physicians will be largely instrumental in the treatment of moral disease. It is to the physician that society will look for the differential diagnosis between the curable and the incurable criminal. Scientific progress will lead us finally to abandon the ancient idea of punishment of crime, and to substitute for it, treatment and correction. The only punishments will be those necessary for the enforcement of discipline in prisons and elsewhere. The treatment of criminals will resolve itself into measures to reform the curable and to protect society against the incurable.

A preliminary necessary to the intelligent treatment of any disease is diagnosis; and this, which is one of the fundamental principles of the science of medicine, is logically applicable to moral as well as to physical or mental

disease. It is universally recognized that the insane are not responsible for their acts to the extent of deserving punishment. The organization of society demands that there be protection against the harmful acts of the insane, and the dictates of humanity call for the protection of the insane against himself. It may fairly be assumed that no mental disturbance taking the form of insanity is without a physical cause, however obscure the cause may be. Is it possible that every moral delinquency has a physical cause? It is certain that nearly every confirmed and incurable criminal has a special leaning toward a certain class of crimes. Is there a physical vice or defect which leads to the commission of these crimes, when conditions are favorable to the full development of this vice and to its expression in criminal acts? These are questions that occupy the minds of criminologists of the present day.

It is often said that the border line between insanity and crime is narrow and indefinite. The plea of insanity, which is so often presented in extenuation of certain crimes, the irresistible impulse which some insane persons have to commit certain crimes—such as homicide, suicide, stealing, arson, etc.—would seem to show that insanity, in some of its phases, readily fades into criminality, or that criminality may be the first manifestation of insanity. Nothing illustrates this idea more strongly than the distinctions that have been drawn between criminality and so-called moral insanity.

To my mind, it should not often be difficult to distinguish between criminality and insanity, provided the data from which to draw a conclusion are full and sufficient. There are the criminal insane and the insane criminal; the one, an insane person who commits crime under an insane impulse; the other, simply a criminal who has become insane. It might be difficult to fix the responsibility of the insane criminal if it were impossible to determine the time when he became insane; but there should be little difficulty in making a diagnosis of the criminal insane. Other difficulties may also present themselves: An outburst of insanity, made evident by a palpably insane act, under the influence of what seems to be a sudden impulse or a recent delusion, has probably been preceded by a delusion or delusions carefully concealed. A criminal act, with-

out insanity, may be discovered, the criminal having, during a long period of years, sedulously maintained the appearance of scrupulous honesty, often assuming the cloak of religion. In some cases of this kind it has been claimed that the person is morally insane and is irresponsible. It has always been found difficult to show that a person who commits a crime against property, with intelligent efforts at concealment, hoping and endeavoring to reap the advantages of his crime or attempting to escape its consequences by flight, is irresponsible, on any theory. A kleptomaniac steals simply because there is an impulse to steal which he can not or does not resist. He does not profit by the crime and has no logical reason for stealing. The criminal, however, always expects and attempts to enjoy a personal advantage as the result of his crime, or he has a reason, which to his criminal mind is logical. The existence of strong temptation, great need or heavy financial burdens, sudden passion which has a logical cause, revenge or hatred engendered by actual injuries or wrongs, afford satisfactory explanations of many crimes and enable us to determine the question of responsibility. I can hardly bring myself to a belief in the existence of what is called moral insanity, excepting the moral defects which are so often observed in dementia and senility, when certain passions remain and the normal power of self-control is impaired.

To Garofalo is due the credit of indicating differences between the criminal and the insane, which are clearly appreciable, with few exceptions. In the insane, the accomplishment itself of the criminal act is the end and object and is in itself a source of pleasure and satisfaction. In the criminal, the act is done as a means of obtaining a material advantage and the act itself may be repugnant. It is the abnormal nature of the pleasure and the fact that no other satisfaction is sought for, which characterizes the insane and distinguishes him from the criminal.

The classification of criminals is not difficult. Havelock Ellis adopts the classification of Ferri, with slight modifications:

The criminal by passion, as a rule, has no criminal characteristics. He simply is lacking in self-control and almost invariably feels remorse. Actually, a criminal from pas-

sion is not a criminal and is not a permanent enemy of society. It is necessary, however, to our social system that he should take the consequences of his criminal acts. He does not commit crimes against property.

The occasional criminal, or the criminal by occasion —the semicriminal of Lombroso—may properly be regarded as belonging to the criminal class. He may or may not have an opportunity or undergo temptation to commit crime; but under temptation and with opportunity, he may commit crime from mere weakness of character. Still, there is no occasional criminal who is without criminal tendencies in a greater or less degree.

Havelock Ellis' distinction between the professional criminal and the instinctive, or the born criminal of Lombroso, seems to me to be artificial. The born criminal frequently presents physical signs of degeneration, and his history often reveals heredity or atavism, his moral criminal characteristics usually being intensified by surroundings. It is thought by some alienists and criminologists that there is often little difference between the born criminal and the victim of so-called moral insanity; but it must be admitted that a born criminal is seldom regarded as insane unless he belongs to the higher classes of society.

The professional criminal may be a born criminal, with physical characteristics, or he may present no physical abnormalities. The high-class professional is always a man of more than common intellectual ability, usually free from small vices and a hard worker. It is quite generally admitted that a professional criminal past the age of thirty can not be rescued from criminal life. The professional criminal is, of course, an habitual criminal; but other habitual criminals there are of less ability, whose methods of exercising their vocation do not entitle them to rank with professionals.

We have little or nothing to do, in a scientific way, with the criminal by passion. Sad experience and remorse may teach him a lesson and lead him to exercise self-control. He must accept the consequences of his criminal acts; but it is our duty, especially toward the young, to provide that he be contaminated as little as possible by surroundings while under control. So it should be with those who offend simply against good order or who are

guilty of what may be termed artificial crimes. It is not a crime to bake or sell bread at prohibited hours or to violate certain ordinances necessary to public decorum or cleanliness. Many men and more women can never be made to feel that it is a crime to evade duties on purchases for their own use; yet the laws in this regard must be enforced. So long as legislators continue to enact new so-called criminal laws every year and officials are compelled to select certain of them to enforce—as it is physically impossible to enforce them all—criminal statistics will never represent the actual detected criminality. Criminality can be studied in a statistical way only from the reports of courts and prisons; and it would contribute much to the accuracy of our knowledge if we could eliminate all except offenses against natural laws and those essential to the integrity of our social system.

In the scientific study of crime the physician has to do mainly with the occasional criminal, the habitual criminal and the born criminal; and in this study, the first thing is to separate these from the offender who is not a criminal and the occasional criminal. He will be forced to rely on the courts for facts in regard to criminal acts. Such and such persons, with such and such an official record, have committed certain offenses; and these persons, on conviction, are turned over to experts for diagnosis and treatment. The ascertainable physical and moral characteristics of the offender may not be useful in the determination of the crime, but they may be very useful in the classification and treatment of the criminal.

The born criminal often presents physical evidences of what is now called degeneration. He has certain physical abnormalities. According to the notions of Lombroso and his followers, without such abnormalities he is not a born criminal. All of the purely physical characteristics observed in the born criminal are present to some extent in the normal man. Some of those which have been described by Lombroso and others are—peculiar skull and facial conformations; left-handedness and ambidexterity; absence or exaggeration of tendon reflexes; abundant hair on the head, with scanty beard; muscular abnormalities; anesthesia and analgesia; unusually rapid recovery from wounds, or "disvulnerability"; obtuse tactile sensibility;

unusual acuteness of vision; defects in the sense of hearing, taste or smell; and many others less marked and regarded as of less importance. Take, however, individual instances in which even a considerable number of these abnormalities exist. We may have a person with a marked peculiarity in skull formation, a heavy jaw, abundant red hair, scanty beard, diminished knee-jerk, defective sense of contact, acute vision, dull hearing, taste and smell, some muscular abnormality, and yet this person may pass through life, honest and upright, showing no criminal tendency even when exposed to temptation and favored by opportunity; but it would be idle to say that in a person who has committed a crime, physical abnormalities found to be more frequent in the criminal than in the normal man, and particularly frequent in a certain class of criminals, may not be of value in classifying the criminal, forming an estimate of his dangerous qualities and of the probability of reformation. A person may have the so-called insane ear or a strikingly abnormal palate, great irregularities in the development of the teeth, and an insane ancestry; and yet we must wait for positive evidence of insanity by word, deed or action before he can be pronounced insane. So physical abnormalities, even with criminal ancestry, are never in themselves positive evidence of criminality.

The weakness in the position that there are any absolute and positive physical tests of criminality is twofold. There is no fixed normal standard of comparison; and the exceptions in which physical peculiarities assumed to be characteristic of criminality exist in normal individuals are very frequent.

On the other hand, the mental and moral characteristics of criminality are fairly positive and definite. Given a number of persons who have committed actual crimes; meaning by this certain offenses against the person or against property, which are violations of natural laws: These include homicides; all kinds of crime against property, with or without violence; felonious assaults; malicious injury to person or property; the aiding and abetting of crime for gain; and other forms of crime which readily suggest themselves. There may be excluded: offenses against good order or discipline, not in themselves crim-

inal; purely social offenses; purely political offenses; honest differences from prevalent opinion on political, social or religious questions; offenses against laws which restrict the natural rights of man; offenses innocently committed through ignorance, etc. The mental and moral peculiarities or abnormalities of these individuals may well be made use of in diagnosis, classification and treatment. Taken in connection with these, the purely physical abnormalities become of considerable importance, as they do in the diagnosis, treatment and prognosis of insanity.

As I have already said, the criminal by passion alone is a normal man, but deficient in self-control under provocation or strong emotion. He presents no criminal history. The criminal act is followed by the deepest regret and intense remorse, usually with a desire for all possible reparation.

The criminal by occasion, or the one who commits a crime when occasion presents itself in the form of temptation and opportunity, may lack physical and moral characteristics of criminality and have no criminal heredity, being simply of a weak and pliable organization. This unfortunate should be treated most carefully, and he should be protected, as far as possible, from influences which may make him an habitual criminal.

The professional and the habitual criminal are the most dangerous enemies to society. Criminals belonging to this class form a criminal organization ruled by the dominating personalities of those of superior intelligence. They may possess few if any abnormalities called degenerative; but they have no feelings of remorse, even for the gravest crimes, are social in their habits, not solitary, and use the argot, or conventional language of criminals and vagabonds, which is never employed by the criminal by passion or the criminal by occasion. The professional usually is not cowardly like the born criminal. He is temperate, prudent, with real friendships, and his sexual ties are seldom more than transient and unstable. These aristocrats of the criminal world have talents and industry which, if employed in legitimate channels, would command respect. With the professional criminal, crime is profitable. Dugdale, the author of that remarkable study of crime called "The Jukes," says: "We must dispossess ourselves of the

idea that crime does not pay." Again he says: "Those who do minor crimes commit about one hundred to one hundred and fifty offenses to one commitment, while those who 'go for big money' get caught once out of five times." A great problem is to make crime unprofitable; but this appears to be excessively difficult. The idea of Garofalo is certainly in the right direction. On conviction of a crime against property, strip the criminal of everything necessary to complete restitution; or if no property can be reached, let the hard labor of the convict contribute as far as possible toward that end. As it is, the innocent sufferer finds it more to his advantage to compound a felony than to aid what is called justice; and often he is deprived of his liberty in a house of detention while the criminal is at large on bail.

It is with the born criminal that the medical profession will have most to do; and the scientific study of this abnormity can not fail to be of benefit to our social system. The born criminal presents certain distinctive mental and moral abnormalities.

Grouping together the professional, the habitual and the born criminal, the same differences in intelligence and education are found as in the honest walks of life. Those who are of a low degree of intelligence are forced to limit themselves to crimes that are within the scope of their mental capacity. They replace intelligence with a low duplicity and cunning; and they often act under the direction of others. These most frequently present physical evidences of degeneration. Experience in reformatories shows that many are incapable of education or even of learning a trade that requires a moderate degree of skill. A large proportion of these are incorrigible. While all authorities agree that education in itself is no bar to criminality, it must be admitted that the discipline involved in education and the avenues which it opens to honest, remunerative labor are favorable elements in reformation when other conditions render this possible.

The chief defect in education observed in criminals is in the line of technical skill. According to the observations of Dugdale, 79.4 per cent. of criminals examined had never learned a trade. This observation is confirmed by all students of criminology.

What Havelock Ellis calls moral insensibility is always observed in the born criminal. It is important to distinguish this from so-called moral insanity. General moral insensibility is a want of appreciation of right and wrong from the criminal's point of view—it may be called perversity or depravity—and criminal acts are not followed by repentance or remorse. Those who are regarded as morally insane have no genuine remorse; and an argument in favor of moral insanity without responsibility is based on the notion that the moral insensibility is confined to a single class of crimes, such as forgery, breach of trust, etc. It is difficult to imagine that a person has a moral defect as regards the crime of forgery, for example, and is entirely honest in other regards. If the idea of monomania is to be discarded by alienists, the idea of moral insanity must also fall. As to the question of monomania, how is it possible that a lunatic shall have a single delusion which argument and experience are incapable of correcting, and yet his intelligence be normal in all other regards! The mental disease may manifest itself in a single delusion which can not be concealed; but none the less is it positive proof of mental disease.

The born criminal never has remorse. This is, indeed, pathognomonic of congenital criminality. Bruce Thompson studied this question in four hundred criminals convicted of premeditated homicide, only three of whom expressed remorse. If it is ascertained positively, after a sufficient period of observation and treatment, that a criminal has no real remorse or repentance, it is almost certain that we have to do with an incurable born criminal.

The general character and mode of life of habitual criminals are interesting and instructive. Such criminals are vain, superstitious, constitutionally lazy and improvident, and are often sentimental and excitable. They are social with their own kind, prone to orgies and to association with a certain class of prostitutes who have the same kind of moral insensibility. They use among themselves the argot, or conventional criminal language, which is quite different from ordinary vulgar slang. They are fond of tattooing. Lombroso says: "Among male criminals the practice of tattooing is so common as to become a special characteristic." The high-class professional is

certainly an habitual criminal and may be a born criminal; but his habits usually are such as do not interfere with the successful exercise of his profession.

It is impossible within the time at my command to do more than refer to the questions of atavism, heredity and environment in their relations to criminality. "The Jukes"—that interesting study by Dugdale—gives an idea of the influence of heredity. The estimates by Dugdale from the facts which he ascertained are certainly reasonable. He calculated that the descendants of one individual, making a family of twelve hundred, entailed on the community during a period of seventy-five years an amount of loss and expense equal to $1,250,000. If any relief is to be expected from the scourge of the posterity of criminals, it is certainly to the medical profession that society must look.

When the diagnosis of the criminal and his classification are not to be obtained from his own record, they can be made only in prisons and reformatories. A criminal less than thirty years of age on his first conviction is certainly an interesting subject for study. The result of such study should class him either as a criminal by passion, a criminal by occasion, a born criminal or a criminal insane. The only way to afford an opportunity for diagnosis and proper treatment is by the indeterminate sentence. The trial by judge and jury merely fixes the crime and its responsibility; it can not bring to light the true character of the criminal and indications for his intelligent treatment. Measuring the punishment to the crime is in the spirit of vengeance, which does not belong to man; it breathes no thought of reformation or of intelligent protection of society. In the words of Van Hamel: "The greatest enemy to the new tendency in the treatment of criminals is the doctrine of penal satisfaction, descendant of 'ancient vengeance, which has the pretension to confide to man a task which can only be reposed in the hands of God.'" "It is not enough," says Wines, "that criminal jurisprudence should be humane; it must also be intelligent."

The law has thrown such safeguards around the criminal that many crimes may be committed with impunity; and criminals frequently escape conviction when there is

no room for doubt in regard to their guilt. There are, however, few unjust convictions. In the examination of nearly a hundred and fifty convict witnesses in the late investigation of the Elmira Reformatory, not more than one or two hesitated to admit their guilt. Dugdale says: " Of those who are essentially not criminal, who are of sound mind and body, honest and industrious and of good stock, there are among State prison convicts from one to two per cent. They are usually committed for crimes against the person." The conviction of an innocent person of honest antecedents must be of extremely rare occurrence.

On conviction of a criminal he should be turned over to the State for treatment. The judge should not fix the so-called punishment. Fortunately laws are not wanting in the State of New York to render possible this beginning of an intelligent criminal judicature. All will admit the value and saving to society of the reformation of criminals; and all criminologists, without exception, regard the indeterminate sentence as indispensable to proper reformatory measures. I copy from " The Sun " for August 14, 1895, the following, which shows that judges have the power to impose indeterminate sentences, with slight restrictions and few exceptions:

" A fact not generally known even among the lawyers who practise in the criminal courts in this city is that the State prison law provides for indeterminate sentences such as are in operation at the Elmira Reformatory. The provision is made in section 74 of the Prison law, which is as follows:

" ' Whenever any male person over sixteen years of age shall be convicted of a felony which is punishable by imprisonment in a State prison for a term to be fixed within certain limits by the court pronouncing sentence, the court authorized to pronounce judgment upon such offender, instead of pronouncing upon such offender a definite sentence of imprisonment in a State prison for a fixed term, may pronounce upon such offender an indeterminate sentence of imprisonment in a State prison for a term with minimum and maximum limits only specified, without fixing a definite term of sentence within such limits named in the sentence, but the maximum limit so specified in the sentence shall not exceed the longest period for which such offender might have been sentenced, and the minimum limit in said sentence specified shall not be less than the shortest term for which such offender might have been sentenced. The maximum term specified in such indeterminate sentence shall be limited in the same manner as a definite

sentence in compliance with the provisions of section 697 of the Penal Code.'

"Succeeding sections appoint the superintendent of State prisons, the agent and warden, the chaplain, the physician, and the principal keeper of each prison a board of commissioners of paroled prisoners for each prison. They are to meet from time to time, and each prisoner sentenced under the law has a right to appear and apply for his share on parole, or for an absolute discharge. The commission is empowered to grant an absolute discharge where it believes that the prisoner will live an honest life. When the members of the commission feel a 'reasonable probability' only, they may parole. Other sections provide for the retaking of prisoners who violate their parole at any time before the maximum term for which they might have been sentenced expires. Although the leading penologists of the world advocate the indeterminate sentence system, the judges of the courts don't seem to take to it. The law has been on the statute books since 1890, and only twenty-eight prisoners have been sentenced under it."

If judges could be brought to carry out this law, a great advance would at once be made in the intelligent treatment of criminals. Every prison should include a reformatory, if for nothing else, to separate those who may possibly be reformed from the incorrigible.

The born criminal, when he becomes an habitual criminal, is and always will be an enemy of society. He can not be reformed; but the safety of the community demands that he be kept under constant surveillance when not actually confined. He is not only dangerous to society at large but his association with the corrigible criminal is a great hindrance to the work of reformation.

The penal code provides for the treatment of the habitual criminal, who was defined by statute in 1881, although the first sentence under the code was pronounced August 29, 1895.

I am indebted to "The Sun" for the following citations:

"NEW YORK STATE PENAL CODE

"690. HABITUAL CRIMINALS.—Where a person is hereafter convicted of a felony, who has been, before that conviction, convicted in this State of any other crime, or where a person is hereafter convicted of a misdemeanor who has been already five times convicted in this State of a misdemeanor, he may be adjudged by the court, in addition to any other punishment inflicted upon him, to be an habitual criminal.—Code Cr. Proc., sec. 510. People v. McCarthy, 45 How., 97.

"691. PERSON, ETC., OF HABITUAL CRIMINAL.—The person of an

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habitual criminal shall be at all times subject to the supervision of every judicial magistrate of the county and of the supervisors and overseers of the poor of the town where the criminal may be found, to the same extent that a minor is subject to the control of his parent or guardian.—Code Cr. Proc., sec. 514.

"692. Effect of Pardon.—The governor may grant a pardon which shall relieve from judgment of habitual criminality as from any other sentence; but upon a subsequent conviction for felony of a person so pardoned, a judgment of habitual criminality may be again pronounced on account of the first conviction, notwithstanding such pardon.—People v. Price, 53 Hun., 188; 24 N. Y. State Rep., 936."

It is thus seen that existing laws in the State of New York provide for the classification of criminals, the reformation of the corrigible and protection against the incorrigible. All that is necessary to a practical reform, which must come in the near future, is a judiciary sufficiently enlightened to act in accordance with the provisions for indeterminate sentence and for the surveillance of the habitual criminal, and a prison organization, intelligent, earnest and capable of carrying out reforms on scientific principles which are now fairly well established. In the work of criminal administration the physician should occupy a prominent place. In the words of Laurent,—"The physician should be the friend and student of the criminal as he is of the insane; should know how to distinguish the alcoholic, epileptic, insane, the vagabond, and morally insane. The prison may remain a prison, and yet be transformed through the results of criminal anthropology. Prisons are inextinguishable mines for material for investigations in this science." The United States initiated practically prison reforms, beginning with the House of Refuge (afterward removed to Randall's Island) in 1825, and culminating in the Elmira Reformatory in 1876; and yet "numbers of prisons exist nowadays which fall far below the commonest requirements of a good prison system." *

The treatment of criminals is one of the great social questions of the day. There is no good reason why we should not take advantage of the studies and experience of criminologists and penologists, treating, without malice or even resentment, the criminal as a patient and crime

* Griffiths.

as a disease; and there is every reason why we should study crime in our prisons in the same spirit in which we study disease in our hospitals and insanity in our asylums. The objects to be kept in view are the cure of the curable by reformation, protection against the incurable, prevention in the way of limiting the development of criminal tendencies in the young and deterring those in whom these tendencies have become developed. Punishment as retribution for crime has no place in this system. Punishment, except as it deters, is of no advantage to society. The spirit of revenge which leads an individual to kill or injure one who has wronged him has no place in the legal protection of members of our social system. What leads so many good citizens to condone crimes against property, if they can secure any measure of restitution, is the fact that it is of no advantage to the injured that the criminal is punished, to a certain extent at his expense and inconvenience. Punishment, however, is a necessary element of discipline; and nowhere is discipline more important than in reformatories and prisons.

The reformatory treatment of criminals is that which appeals most strongly to us as members of a profession whose mission is to alleviate suffering and preserve health and life. We do not ask—Is it worth while to attempt to reform criminals? but simply—Can they be reformed? On this question I can speak with the advantage of some experience.

In 1894 I had the honor to be a member of a commission of investigation of the New York State Reformatory at Elmira. This investigation continued for about six months; and during that time I made a careful study of the methods of the institution and the results obtained. These results are most encouraging to those interested in prison reform. The system—which time does not permit me to describe fully—involves discharge on parole after a certain period of treatment. It is estimated—and the estimate seems fair—that out of 3,725 paroled from 1876 to September 30, 1893, 3,051 were reformed, or 81.9 per cent. Out of 4,797 indefinites discharged, "whether by parole, expiration of maximum term, or any other way, the percentage of reformations was 63.6." These calculations are based to some extent on estimates. In 1887 and 1888 an

effort was made " to verify the estimates of probable reformation as to 1,722 prisoners who had been paroled prior to September 30, 1887." Inquiries to prisons, relatives, employers, and acquaintances of the men were made. Definite information was received as to 1,125 of those paroled. Of that number reliable information was received that 78.5 per cent. had not fallen into crime. This would give a percentage of 51.28 known to have been reformed out of a total of 1,722 paroled. After six months of satisfactory conduct on parole a prisoner receives an unconditional release.

The Elmira Reformatory receives males between the ages of sixteen and thirty, after their first conviction of a crime punishable by confinement in a State prison. They can not be confined longer than the maximum term of imprisonment for the offense of which they have been convicted. The minimum term of confinement is not fixed. On admission a full description is taken, including mental capacity, moral qualities, education, occupation, previous surroundings, parentage, possible hereditary tendencies, etc. The inmate is put first into an intermediate or probationary grade for six months. For bad conduct he may be at any time reduced to the lowest grade. After good conduct for six consecutive months he is advanced to the highest grade. It is possible for an inmate to earn his parole in twelve months. The average time of detention of those paroled, for six years prior to September 30, 1893, was twenty-two months. The average maximum term of all indefinites received during the same period was five years and nine months.

The reformatory includes a prison, a school of letters, a school of technology, a school of physical training, a number of manufacturing departments and a military organization. The trade schools embrace thirty-four different trades, and gave instruction, in 1893–'94, to about eighteen hundred inmates. Although carried on primarily for instruction and not for profit, the manufacturing departments realized $53,458.47 profit for the year 1892–'93.

Under the Elmira system no inmate is paroled until he has a situation provided for him and enough money to his credit to support him until he receives his first month's wages. He is under surveillance for six months and may

be returned to the reformatory at any time within this six months should he violate the conditions of his parole.

The agencies which operate in bringing about these remarkable results are the following:

1. The indeterminate sentence, which gives hope of release and incites to efforts at reformation on the part of the inmate.

2. The strict and inflexible discipline, including military training. Most inmates have never been taught self-control and have never been subjected to discipline.

3. Physical training, with no opportunity for committing excesses of any kind.

4. Removal from surroundings and associations of a demoralizing character.

5. Educational and technical training.

Pike, the author of "History of Crime in England," says: "There is one great preventive for crime, one great antidote to instincts inherited from the past, and that is education."

To summarize: a criminal by instinct, his criminality fostered and developed by surroundings, illiterate, without a trade or means of earning an honest living, with a feeble and vicious physique may be discharged from the reformatory on parole, physically well and strong, with an education not beyond his station, a skilled mechanic with good employment under honest surroundings. He has six months in which to learn self-reliance and is then a free man. The Elmira Reformatory well deserves its position as the model institution of its kind.

It is so rare that a criminal more than thirty years of age—except the criminal by passion and the criminal by occasion—is reformed, that such are excluded from the benefits of purely reformatory institutions. The objects in the treatment of these and of the incorrigible younger criminals are the protection of society and deterrence by example and fear of consequences of crime. Imprisonment and protracted surveillance of habitual criminals is an essential element in the protection of society against the habitual criminal—and an imprisonment that has no attractions of any kind. Imprisonment at hard labor, the prisoner supported by the barest necessaries of life, with rigid discipline and persistent surveillance after re-

lease, is what is required, not as retribution, but for protection alone. A dangerous man, like any dangerous animal, should be prevented from doing harm. We confine a dangerous lunatic, largely for our own protection, but not under conditions intended to deter men from becoming insane or to deter other lunatics from committing violent acts, as is evident. Although an habitual criminal may be one by heredity and instinct, he still is capable of a certain self-control and can appreciate the consequences of criminal acts. When these consequences show little chance for profit and involve seclusion from society, at hard labor—which is always repugnant to the born criminal—and with no comforts or distractions, they can not fail to exert a deterrent influence; but humanity demands that criminal jurisprudence and administration should carefully separate from the class of incorrigible and habitual criminals the criminals by passion and by occasion.

The idea of restitution and reparation enters very little into existing methods of treatment of criminals. Crime should be rendered as little profitable as is possible; and in simple justice, the State should force the criminal to make restitution and reparation to the injured to the fullest extent practicable. Nothing will more efficiently deter crime than taking away or largely diminishing the profits of criminal acts. This idea of restitution and reparation pervades the Italian school of criminology and is well represented by Garofalo. Speaking of a certain class of crimes against property, Garofalo, quoted by MacDonald, says:

> "For this there is nothing better than the forced payment of the fine and damage to the injured party. This would produce other advantages to society. An unfaithful cashier or fraudulent bankrupt would know that if once discovered he could not enjoy the smallest part of the money stolen, but would have to return all, every penny, or otherwise he would have to work for an indefinite time for him whom he had robbed. This is a forcible way of causing the sudden reappearance of the sum that might be thought to be in the hands of consorts. This is much more useful than imprisonment for a fixed time, which is no profit to any one, and only adds to the damage from the crime the expense of supporting the prisoner. If the money has really been spent the offender must work without respite for the repayment of the injured party. If he will not do it voluntarily, he will be obliged to do it by working for the State, where there is no bread without labor. If, in spite of his efforts, he is unable to gain a sufficient sum, after

a certain number of years, according to his age or his good will, this constraint can be fixed to ten or fifteen years; but this term should be lengthened as soon as a want of assiduity is noticed. If the delinquent fulfils all his obligations, he is to be released, and deprived only of his political rights, with interdiction of any public function, or of exercising commerce, if it is a case of a bankrupt."

It is evident that the subject I have chosen is too large to be considered adequately in a public discourse of reasonable length. The treatment of those guilty of crimes simply against the person, including homicide and murder, of sexual perverts, vagabonds, tramps, beggars, alcoholics "et id genus omne" must be passed over. Alcoholism and prostitution exist and will exist. What shall be done with alcoholics and prostitutes, are questions of great importance and problems that the medical profession should attempt to solve. These problems can not be considered here; but I can not refrain from a brief discussion of capital punishment.

Capital punishment eliminates the criminal and relieves society from the dangers that might come from his possible posterity. The execution of criminals is a simple and easy method of extermination. Aside from a satisfaction of the idea of retribution, the advantages to society of extermination, and the supposed deterrent effect of executions commended to jurists the severe punishments that were inflicted in the last century. Blackstone, writing about the middle of the eighteenth century, says that no less than one hundred and sixty crimes were made punishable by death in England by acts of Parliament. The cruel and atrocious tortures and punishments in earlier times, mainly the offspring of fanaticism, may well excite our horror. The Inquisition, with nearly three hundred and fifty thousand victims between 1491 and 1808, and the hanging of persons accused of witchcraft at Salem in 1691 and 1692, are shocking examples of legalized cruelty. At the present day capital punishment practically is limited to the crime of murder.

It is generally conceded that a man has a moral right to take the life of another in defense of his own; but have we a moral right to take a human life, either in the exercise of retribution, to prevent subsequent harm at the hands of the criminal or to deter, by example, others from taking life? If it is criminal for an individual to take the

life of another from motives of vengeance, it is equally criminal for society to take a human life as punishment for crime. At times of great danger it may be necessary to sacrifice human life to preserve discipline; but this is a measure of self-defense. We certainly should be able to prevent a murderer from repeating his crime without committing a legalized murder. The only argument, to my mind, that remains in defense of capital punishment is that it may be deterrent.

The arguments advanced by the advocates of capital punishment certainly are strong. Garofalo says that murders always increase in proportion as the severity of the punishment for this crime is relaxed; and he cites statistics from Belgium, Italy, Great Britain, Switzerland and France in support of the view that the effect of capital punishment is deterrent. On the other hand, there are strong arguments in support of the proposition that capital punishment is not deterrent. That public executions are demoralizing and brutal, every one will admit. The moral insensibility of murderers is well known, as well as the bravado of those who pose as heroes and the emotional displays of those who profess repentance and "change of heart." MacDonald quotes a statement, that out of a hundred and sixty-seven persons condemned to death in England, a hundred and sixty-four had been present at executions.

The argument which I shall present against capital punishment—one that I think can not be successfully controverted—is that the taking of human life as a punishment for crime is in itself a crime, is a relic of barbarism and unworthy of our present civilization. No physician can consistently countenance the taking of human life. As we can not and will not mercifully do this to put an end to suffering in cases of incurable disease or in the case of a dangerous and hopeless lunatic, much less can we approve of it as a punishment or to deter possible criminality in others. We may destroy the life of an unborn child to save the life of the mother; but it is always with reluctance and extreme repugnance to the act. Compared with acts of savage brutality, such as cannibalism, I may quote, with MacDonald, the words of Montaigne, who says, "It is more barbarous to kill a live man than to roast and eat

a dead one." I need not go very far back to find acts provided for and sanctioned by law and so-called necessity which civilization would not tolerate at the present day. Before Pinel, in 1792, with his own hands removed the chains from lunatics at the Bicêtre, the conditions of confinement of the insane were horrible almost beyond description. The tortures of criminals and suspects a few decades ago were worthy only of savages; and many of the executions were brutal murders. When John Howard made his inspections of penal institutions in 1773, the prisons were hells upon earth. As scientific progress has brought about reforms in the treatment of the insane, so the same spirit should remove the last glaring relic of barbarism, capital punishment. It is an unworthy reproach to science to assert that society has but one way of deterring the greatest of all crimes, and that is by repeating the crime itself under the cover of law. Even in the punishments that are necessary to the enforcement of discipline, the "golden rule" laid down by Pike should be observed: "Let them not afford an evil example of cruelty to the spectators."

Emancipation from fanaticism and bigotry is the first necessity in the intelligent treatment of crime. Fanaticism is responsible for the early persecution of scientific discoverers, such as Galileo, for the persecution of Jews, the massacre of St. Bartholomew and the numberless crimes committed in the name of the divine right of kings. The Puritans landed in America in 1620 to escape religious persecution and to enjoy religious liberty; and they hanged witches in 1692. No great progress can be made in the reform of criminal jurisprudence until the laws based on bigotry and intolerance of personal and religious liberty are removed from the statute books.

It is to the physician and the scientific student of crime that we must look for real reforms. The history of criminality is full of warnings of dangers incident to existing systems in the treatment of crime, and the greatest of these dangers is heredity. The history of "The Jukes" conveys this warning in the strongest possible manner. We are justified by public opinion in protecting ourselves from the dangerous insane by perpetual confinement. The dangers we have to provide against from the habitual criminal

are much greater, as he is an enemy with more or less intelligence, acting with method and in concert with others. All criminologists agree that such criminals, when irreclaimable, should be put under perpetual confinement or surveillance. Dugdale says:

> "In dealing with the habitual typical criminals who are contrivers of crime, criminal capitalists and panders, where we can not accomplish individual cure we must organize extinction of their race. They must sternly be cut off from perpetuating a noisome progeny either by the propagation or perversion of a coming generation. The old laws attempted this extinction by hanging; but for us it must be perpetual imprisonment, with certain mitigations to guard against barbarity. For this class, congregate imprisonment is perhaps the most suitable."

Dugdale evidently did not care to suggest a method of organizing "extinction of their race"; but one less severe than hanging readily suggests itself. It would not be difficult to devise a method of sterilization of irreclaimable born criminals that would not offend sentimental public opinion; this to be applied, not as a punishment for any particular class or classes of crime, but merely for the protection of society and after a full scientific investigation of every case.

In concluding my very inadequate treatment of the questions considered in this discourse, I do not make any formulated suggestions; but it must be evident that criminology and penology should receive more attention at the hands of the medical profession. The State of New York is the birthplace of practical penal reform. Let her do her full share now in the good work! While it would be desirable to adjust criminal laws so as to bring them in accord with the present scientific status of criminology, existing laws admit of important reforms. A scientific spirit might be infused into the prison commission if it included members of the medical profession. Physicians to prisons should study criminals according to modern methods and not simply prescribe for their bodily ailments. Much study and accumulation of material is necessary to bring criminal anthropology to a condition approaching a positive basis, and for this work criminologists look to the medical profession. As I have already said, I venture to hope that criminology and penology will not be neglected by the New York State Medical Association.

LX

THE PAIN OF DEATH

Address before the "Quill Club," April 20, 1897.

It is likely to be a difficult task to convince the people, or even the few who think and reason for the people, that criminology is a most useful science; and that the utility of the methods which have brought this science to its present state must be so impressed upon law-makers and jurists as to produce radical changes in the existing systems of criminal jurisprudence. The alternative is a continued increase in crime, with its attendant pecuniary burdens, and increased danger to our social organization. Certain statistical facts bearing on this question must be accepted. The annual cost of the machinery for the detection and punishment of crime in the United States, according to a recent report of the Ohio Board of State Charities, is fifty-nine million dollars. The half century closing with 1899 probably will show an increase more than fivefold in the proportion of those imprisoned for crime. In 1850 the ratio of prisoners to population was 1 to 3,442. In 1890 it was 1 to 757. The expense borne by the people is not limited to the punishment and support of criminals, but is largely extended by individual losses in crimes against property. Restitution to the loser has a small place in the treatment of crime. The controlling idea is punishment of the criminal; and justice to the victim is but little considered. What wonder is it, then, that crimes against property are compounded by the injured at the price of partial restitution! If the ratio of increase of crime should continue, a revolution in criminal jurisprudence within the next half century is inevitable.

Advanced criminologists are almost a unit in accepting the idea of intelligent treatment instead of punishment of

criminals; but while it eliminates punishment, it is an error to suppose that the treatment of criminals relieves them of the consequences of criminal acts. Criminologists advocate measures for the prevention of crime, the reform of the criminal and his restoration to usefulness when possible, and above all the protection of society against incurable criminals. Intelligent treatment can be based only on a knowledge of the natural history of criminals and what may properly be called their morbid anatomy and the pathology of crime. It is evident that I am looking at crime from the point of view of a physician; and, indeed, the methods that have been used most successfully in the investigation of disease may well be applied to the study of crime, which is the most important and dangerous disease affecting the social system. Whatever may be the cause of disease and however much physical and mental ailments may be due to the ignorance, faults, vices or even crimes of those afflicted, it is the province of the physician to alleviate suffering, restore health and save life, however worthless or even dangerous to society some lives may be. The element of punishment does not enter into our treatment of patients; we do not kill to protect society from contagion or other harm; we do not kill even to relieve hopeless suffering or to spare society the pain of caring for the incurable insane, idiotic, imbecile or deformed; much less do we induce disease in order to learn to cure it or to deter others from vices which surely lead to physical and mental maladies. We study disease on scientific principles; and we endeavor to become acquainted with it in all its phases, regarding it as an enemy to human happiness which it is our duty to combat by every means that can be used for its prevention, cure or the mitigation of its ravages.

We recognize that disease is always with us. When all shall be born without taint or defect or danger of inheritance from the misfortunes or sins of ancestors, shall have most judicious care until able to care for themselves, shall learn how to live in exact accordance with natural laws, and shall be free from inordinate appetites, ambitions and passions, there may be no disease and the race may then be subject only to accidents or the decay of old age. When to all this are added freedom from envy, hatred and malice,

general content and success in the pursuit of happiness with universal recognition of natural social laws, there may be no crime; but now crime must be recognized as one of the greatest of social problems. As physicians study disease without prejudice or passion, so crime should be studied. As the final object in the study of disease is to subject it to intelligent treatment, so the object in the study of crime should be to treat it in the best interests of society. One may well talk of human justice, but who is to fix the standard; and is it not true that so-called justice now includes the idea of vengeance, punishment and retaliation! When criminology shall have advanced so far that law-makers and those who administer justice have become educated to a recognition of its scientific principles, punishment of crime will be replaced by judicious treatment of the criminal; without sentimentality, the treatment of criminals will be tinged with humanity; but in the words of an eminent authority "it is not enough that criminal jurisprudence should be humane; it must also be intelligent."

Much study has of late years been given to what may be called the anatomical characters of crime, as shown by stigmata and signs of physical degeneration; but many individuals with distinct signs of degeneration are not criminals in the sense that they ever are guilty of crime, and many criminals present no evidence of physical degeneration. Future study may enable the criminologist to recognize positive physical evidence of criminality; but at present a careful study of the moral characters of criminals seems likely to produce the best results.

In the diagnosis of crime, the dispassionate and rigid application of scientific principles is most important. Judges, controlled largely by precedent and ancient jurisprudence and unaccustomed to scientific methods, and juries usually selected for want of intelligence and interest in current affairs, influenced by sympathy or a spirit of revenge and often swayed by eloquence instead of reason, are expected to settle the most delicate points in criminal diagnosis and responsibility for criminal acts. Under existing methods, pseudo-scientific experts, far from giving aid, often add confusion to criminal jurisprudence, by conflicting testimony; and who shall decide which "ex-

pert" advocate is right! The true value of expert testimony can be estimated only by a disinterested expert. It must be remembered that truth is immutable; and with sufficient positive data, it is impossible that two contradictory scientific opinions should have equal value. Until judges can obtain and will make use of competent and disinterested scientific advice, there will continue to be many miscarriages of so-called justice. How such advice is to be secured is a problem to be solved by intelligent legislative bodies. The prospect for even a recognition of this as a question for consideration at the hands of our law-makers is not encouraging.

The prognosis of criminality, taking into account the usual treatment of the criminal, is not difficult or uncertain. If the crime itself has certain fixed limits of punishment, and that is all, it is easy to predict the future of one convicted of his first offense. He is practically marked for life as an outcast and an enemy of society; he is thrown in with criminals by profession, and the spirit of revenge and antagonism to law is fostered; an honest life is rendered so difficult as to be practically impossible; he is one more added to the criminal classes. This system is so patent, and so inimical to the best interests of society, that it is well recognized. The most important step toward correction of this evil is the indeterminate sentence and the reformatory system, and better still, these combined with the probation system of Massachusetts. A full discussion of these systems would be out of place; but it may be said here that their results are most remarkable. In a recent investigation of the Elmira Reformatory, it appeared that 81.9 of the men paroled prior to September, 1893 were reformed, according to the estimate of the managers. Taking, however, a total of 1,772 prisoners paroled prior to September 30, 1887, definite information was obtained in regard to 1,125; and it was ascertained that 78.5 per cent. had not fallen into crime, or 51.28 per cent. of the total of 1,772 paroled. It is said that the results of the probation system, with supervision and no imprisonment, are even more striking.

It is not difficult to recognize the habitual criminal and the confirmed and permanent enemy of our social system. Society must be protected against him as against wild

beasts or pestilence. A simple method of such protection, and one which was long employed, even in countries of the highest civilization, was by killing, attended with various penalties more or less cruel and revolting intended to deter others from committing crime. While this certainly removed social enemies, it gradually appeared that it did not deter; and the pain of death is now practically confined to the crime of murder. That the punishment of death for murder actually deters is by some considered an open question; certainly public executions do not. The death penalty is seldom swift and is always uncertain. For the years 1882 to 1891, inclusive, the number of murders in the United States increased from 1,467 to 5,906. In 1882 eight per cent. of the murderers were executed; and in 1891 only two per cent. Popular dissatisfaction with the uncertainty of punishment for murder has been expressed by the fact that in ten years the legal executions numbered 1,246 and the lynchings 1,576. These statistics were collected by General Newton Martin Curtis, of New York, a vigorous opponent of the death penalty.

Fully as important as are measures for the prevention of disease, such as public and private sanitation, quarantine and vaccination, are those for the prevention of crime. Moral sanitation, by improvement in the surroundings of the poor, drainage from our large cities of the refuse youthful population into the rural districts, amelioration of the condition of the young who labor under oppressive taskmasters, and best of all, suitable education constitute one way of preventing vice and crime. A great fault in our social system is unsuitable education, unfitting many who should labor with their hands for occupations proper to their station in life and crowding the already overflowing class of educated poor. Our public schools, admirable as they may seem, much more frequently fail than succeed in preparing the children of the masses for their life's work. Certain studies, even if successfully pursued, give worse than useless accomplishments when they take the place of proper manual training. The Elmira Reformatory is really the best school that I know for the social class which it educates. Its only drawback is the stigma of crime which attaches to its graduates. The entire school system of great cities is, in my opinion, in need of reforma-

tion; a great part of the education there acquired tends to swell the number of unemployed and has little value as a means of honest livelihood.

Of all the preventives of crime, respect for law is, perhaps, the most efficient. The object of law should be to protect personal rights and personal liberty and secure the greatest happiness to the greatest number; and to this end laws should be intelligent, free from prejudice and bigotry, and should never oppress one class for the benefit of another. One great evil is the constant creation of artificial crimes by statute. Every intelligent man or woman knows that certain offenses against the person or against property are crimes and that certain ordinances are necessary for the preservation of public order, health and comfort; but all have a sense of personal liberty and personal rights, which organized society can not properly invade. It is difficult to convince the people that an act which is harmless and lawful at one time is criminal an hour later; that a citizen may rightly be arrested for buying or selling milk or bread at a time when he may lawfully buy tobacco or sweetmeats; that he may be induced under various pretexts, by an officer of the law, to commit an offense that offends no one, so that he may receive exemplary punishment. All these conditions exist in the city of New York; and they certainly do not promote respect for law, even in the law-abiding and orderly classes.

An ideal measure of prevention of crime is the rendering of crime unprofitable. As it is, crime is not unprofitable; and with many, our social system has rendered it a necessity. Dugdale, the author of a study of crime called "The Jukes," says: "We must dispossess ourselves of the idea that crime does not pay," and again, "Those who do minor crimes commit about one hundred to one hundred and fifty offenses to one commitment, while those who go for 'big money' get caught once out of five times." The sufferer from a crime against property finds it more to his advantage to treat with the offender than to bring him to justice; and in many instances he is himself deprived of his liberty in a house of detention while the criminal is at large on bail. How crime may be made unprofitable and honesty always the best policy, how restitution, instead of additional inconvenience and injury, may be made to the

innocent sufferer, are problems as difficult as they are important.

At some future time, probably very remote, there will be no such thing as human punishment, and all criminals will be subjected to scientific treatment. The indeterminate sentence and a probation system will eventually become universal. This will bring about more extended prevention, a large proportion of cures and better protection of society. As the science of criminology advances, we shall be better able to separate the curable from the incurable criminal, reclaiming one and protecting society against the other. If the idea of vengeance can be eliminated, we shall be able to treat intelligently the criminal by passion and the criminal by occasion, who really are not criminals, as physicians treat an acute and self-limited disease. Crime will then be regarded as a moral disease, and the criminal as a patient. It is not to be understood that, the idea of punishment being eliminated, the chronic criminal will not be made to suffer and will not be restrained. There should be no difference practically between the treatment of a confirmed criminal and a dangerous lunatic; the one as well as the other should be prevented from doing injury. This idea is not Utopian. It will be realized, probably in the distant future, as one result of a dispassionate study of criminology and penology, when these sciences shall be pursued in the unemotional and unsentimental spirit in which we study the science of medicine; but there are great obstacles in the way of progress in this direction. The greatest of these is capital punishment, the very embodiment of the idea of retribution and vengeance. This must disappear. It is more than three thousand years since it was written "Whoso sheddeth man's blood, by man shall his blood be shed," and "Eye for eye, tooth for tooth, hand for hand, foot for foot." Revenge does no good; it is a feeling born of passion which has no place in either criminal or civil jurisprudence. It is sometimes justified, but without justice, by public sentiment, as in homicides in retaliation for crimes against the family, or in lynchings for atrocious murders; but in these instances the wreaking of private or popular vengeance is to a certain extent an expression of want of confidence in law. Both society and law justify

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the taking of life in self-defense or on occasions of great danger to preserve discipline; but this is quite different from the deliberate taking of life in cold blood after a formal trial. We certainly should be able to prevent a murderer from repeating his crime without committing a legalized murder; and the only logical support that remains for capital punishment is that it may be deterrent. There are, however, some apparently strong arguments supported by statistics in favor of capital punishment. It has been said that murders always increase in frequency in proportion as the severity of punishment for this crime is relaxed; and statistics from Belgium, Italy, Great Britain, Switzerland and France are cited in support of this view; but in order to deter, the death penalty must be prompt and certain, and this can not obtain under our present penal system. On the other hand, it is generally admitted that public executions are demoralizing and do not deter. The history of murderers almost always shows a degree of moral insensibility which is perhaps comprehended only by the criminal classes. In many instances executed criminals display a vanity and bravado which lead them to pose as heroes, and they are so regarded by their class. Others are brought into a sort of hysterical condition and make emotional displays of repentance and "change of heart." Emotional repentance of this kind is "a delusion, a mockery, and a snare"; it has no element of true repentance or of remorse. If there is any one thing that has been definitely ascertained by criminologists, it is that the born or habitual criminal has no remorse, even when he has committed murder. Bruce Thompson has made a careful study of this interesting question. He examined four hundred criminals convicted of murder with premeditation and sentenced to death. Only three of this number expressed remorse, and there is doubt if in these instances it was genuine. It is now considered certain that when there is no real remorse or repentance, we have to do with an incurable criminal who can not be deterred from committing crime by the exemplary punishment of others. In my opinion the death penalty does not deter; and if this is admitted the last vestige of justification of capital punishment is swept away. Nevertheless, under our laws, those convicted of capital crimes

must be sentenced to death. Judges, whatever may be their opinions, have no alternative; law-abiding citizens on juries must do their duty; if experts are permitted to aid in acquitting the guilty on the plea of irresponsibility, other experts should not hesitate to aid in carrying out the law; but the death penalty, so long as it remains in our system of criminal law, should be sure and prompt. The strict and impartial enforcement of a law affords the best means of determining whether or not it fulfills its objects.

A true physician is the embodiment of mercy and philanthropy. His mission is to relieve suffering, restore health and save life. He should represent the best sentiments of society; and how can he, as such representative, consistently do anything but condemn the taking of human life! Until physicians feel justified in killing sufferers from incurable diseases, the hopelessly insane, the deformed and idiotic—which will never occur—they can not logically advocate the death penalty. Savages kill those who become burdens to them, but not civilized peoples illuminated by the light of medical science. We are fully justified in protecting ourselves from the dangerous and incurable insane by perpetual confinement; and we are equally justified in treating in the same way the habitual criminal, who is more dangerous than the insane, as he has intelligence and acts with method and in concert with others; but these measures of protection should be tempered with mercy. Society was none the less protected when Pinel, in 1792, struck the chains from the unfortunate lunatics in the Bicêtre, whose conditions of restraint were horrible beyond description, or after Howard inaugurated prison reforms in 1793. We must look to the physician and the criminologist for real reforms in the future; and it is not without its use to compare the criminal with the patient and the treatment of crime with the treatment of disease.

LXI

THE USE AND ABUSE OF MEDICAL CHARITIES IN THEIR RELATION TO MEDICAL EDUCATION

Published in the "Report of the Proceedings of the Twenty-fifth National Conference of Charities and Correction" in 1899.

It would be difficult to exaggerate the importance of medical science in its practical applications to the conditions which contribute to the happiness and prosperity of civilized peoples. Using the term "medical science" in its widest sense, so as to include the physiology and pathology of the mind as well as of the body as a basis for the intelligent treatment of diseases and injuries and mental disturbances, and, most important of all, the prevention of disease, is there any individual or community or nation that does not profit directly or indirectly by advances in medical knowledge! The benefits derived from such advances are not confined to any one people or limited by time or place. It is probable that every person here present enjoys the benefit of practical immunity from smallpox; and for all time and in all parts of the civilized world the blessing of exemption from this terrible scourge, given to us a century ago, will be felt.

The same may be said of the abolition of the agony and horrors of severe surgical operations by the discovery of artificial anesthesia, which is within the experience of many surgeons now living. If it should seem visionary now, it will not appear extravagant in the near future if one should predict the practical extinction of many infectious diseases, such as consumption, diphtheria, typhoid fever, yellow fever and scarlet fever. A hundred years ago any one predicting that smallpox would ever be so far conquered as to become a rare disease due to neglect of a simple precaution would have been regarded as men-

tally unsound; and yet, at the Jenner Centenary, held in Berlin in 1874, Virchow stated "that all peoples that had not been reached by vaccination or that had not accepted it had disappeared from the face of the earth, destroyed by smallpox." Jenner's discovery was based on the simple observation that those who had contracted cowpox were protected against smallpox. It was a discovery based on observation and experiment only, involving no idea of the mechanism by which immunity was secured. Pathogenic microörganisms were then unknown; and nearly a century elapsed before apparatus and methods were devised by means of which these organisms could be seen and studied. With modern microscopes and staining processes the mechanism of the production of many infectious diseases has been ascertained, the reason why these diseases are self-limited is understood and we are at the threshold of a thorough comprehension of immunity. Is it extravagant now to predict that many of these diseases will eventually disappear from the face of the earth!

Extension of the benefits of advanced medical science depends largely upon thorough medical education; and there is no more important factor in advanced medical education than the study of actual disease with the examples afforded by medical charities. Medical charities may be and are abused, as every form of charity involving relief of want or suffering may be and is abused. It may be said, however, that the more unworthy the recipient, the greater the charity,—but with certain limitations. Still, charity that is not needed is not charity, but is simply imposition and fraud. The impostor receives, makes no return, and often he deprives others of much-needed relief. This important side of medical charities will be discussed by others. In my opinion the only question involved is the moral question; and the bearing of the abuse of charities on the income of the physician, now often discussed, is secondary. While the physician is justly entitled to proper remuneration for his labor, the profession of medicine is essentially unmercenary. The highest aim, indeed, of the physician is the prevention of disease, which necessarily reduces his income.

In the relations of medical charities to medical education the recipient of charity always makes more or less

return. At the present day there are few pauper hospitals or dispensaries that do not contribute something to medical education. Attending physicians and surgeons to hospitals and dispensaries receive no pecuniary compensation. Their reward is the knowledge and experience they acquire for themselves and opportunities for teaching medicine. Within my own experience of forty years as a medical teacher, the use of medical charities in medical education has been immensely extended. Forty years ago many physicians were educated in the schools and received their diplomas without having ever seen a case of disease or injury except in the most incidental way. Many medical schools had no clinics as part of their required curriculum. Now it is impossible for a medical school without some clinical opportunities to exist.

I can not illustrate the use of medical charities in their relation to medical education better than by giving a brief sketch of the practical work required of a medical student of to-day, all of which practical work is dependent upon medical charities.

A medical student, during at least the last two years of his course of instruction, is required to attend lectures on actual cases of disease or injury, witnessing surgical operations. In addition he is taken into the wards of a hospital and instructed in diagnosis, treatment and the application of surgical dressings. He is practically instructed in the modern aseptic and antiseptic surgical technique. He is required to attend, under supervision, at least six cases of labor. If a student should get the full benefit of this practical course, he brings to his aid a certain experience even in his first case in private practice, he is able to avoid infection in his first surgical operation, and in his labor cases the element of danger is reduced to the minimum. The existence of medical charities alone renders this education possible.

Patients contributing thus to medical education receive, from their point of view, much more than they give. With all due respect for older members of the profession who have been for years engrossed in private practice and are almost of necessity unfamiliar with recent advances in pathology and therapeutics, it is not too much to say that their methods do not always give patients the benefit of

modern science, although their clientele may be among those amply able to secure the best medical attendance. On the other hand the inmates of a pauper hospital have their cases investigated in the light of medical science as it is to-day, and are treated secundum artem. Of necessity this is so. A clinical teacher can not sustain his position in a hospital unless he is fully abreast of the present state of medical science, which reduces accidents and errors in the practice of medicine, surgery and obstetrics to the minimum. In "Bellevue," the great pauper hospital of the city of New York, for many years practical politics has stopped short at the medical management. With an experience and observation of this institution extending over nearly forty years, I can not call to mind a medical or surgical requisition that has been dishonored or a well-founded complaint of lack of care and attention to patients, even when requisitions called for supplies, remedies, instruments or apparatus of the most expensive kind. The same may be said of nearly every hospital and dispensary, public or private, in the large cities of the United States.

The great hospitals are the practical schools for the modern "trained nurse." The internes are carefully selected by competitive examination, and they represent the flower of the younger members of the profession. When we bring these facts to mind, and remember, also, that even the smallest surgical operation, performed with proper precautions, involves a considerable expenditure for dressings, etc., which many in moderate circumstances are unable to buy and which the practitioner whom they can afford to employ is unable to furnish, can we wonder that many who can pay small fees only, and must receive corresponding service, seek free treatment which is of the highest grade! The statistics of the society of the Lying-in Hospital, which treats patients of the poorest class, in their filthy and squalid homes, under the most disadvantageous surroundings, show a mortality that is almost nil. Few physicians in private practice can show such a record. The actual expense of treatment in such cases, to say nothing of fees, is more than many of the working classes are able to pay.

I say nothing of abuse of medical charities in their relation to medical education, for I fail to see what and

where the abuses are, if indeed they exist; and looking at medical charities solely in their relations to medical education, their use and importance can hardly be overestimated. Medical charities are the foundation of medical education; and while much is given in charity, much is received in return. There are heroes of war, who give up their lives on the field of battle for country and for principle, and medical heroes of peace, who brave the dangers and horrors of pestilence to save life; but the homeless, friendless, degraded and possibly criminal sick poor in the wards of a charity hospital, receiving aid and comfort in their extremity and contributing each one his modest share to the advancement of medical science, render even greater service to humanity. Whether a patient is restored to health and to his measure of happiness or succumbs to the inevitable, he does something to educate men for the exercise of the most beneficent and disinterested of professions; and this is the use of medical charities in their relation to medical education.

LXII

RABELAIS AS A PHYSIOLOGIST; REFLECTIONS SUGGESTED BY HIS DESCRIPTION OF THE PRODUCTION AND MOVEMENTS OF THE BLOOD, IN 1546

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It is difficult to put oneself in a position to appreciate, with a reasonable degree of accuracy, the condition of knowledge common to scientific men of the period upon any one subject, at a time so remote as three and a half centuries; yet I have attempted to do this in regard to knowledge of the movements of the blood, in the middle of the sixteenth century. We can hardly imagine an accurate and useful knowledge of the physiology of nutrition, absorption, digestion, respiration, or secretion as existing before the discovery of the circulation by Harvey, in 1616; and this discovery was so momentous in its influence upon the science of medicine that its history anterior to the publication of the "Exercitatio anatomica de motu cordis et sanguinis" (1628) has been, perhaps, the most interesting chapter in the literature of physiology. Not only did this great discovery mark one of the most important epochs in human knowledge, but it indicated a method of observation of phenomena and of reasoning from such observation, that has been of inestimable value to all succeeding generations. Flourens, in his history of the discovery of the circulation, says that "this little book of an hundred pages is the most beautiful book in physiology." Harvey's book was nearly contemporaneous with the "Novum Organum and Advancement of Learning" of Bacon and with the immortal studies of humanity by Shakespeare. Did Harvey, as a disciple, follow the methods of inductive science founded by Bacon or did Bacon formulate a method suggested by the researches of Harvey, or were these two

great minds independent of each other, are questions that can not be satisfactorily answered. All that can now be said is that the great investigator and discoverer illustrated the scientific method indicated by the great philosopher.

In the history of the development of the doctrine of the circulation, everything relating to the blood and its movements is of interest. Perhaps the most exhaustive and accurate account of knowledge of physiology anterior to the time of Harvey is in the encyclopedic work of Milne Edwards ("Leçons sur la physiologie," Paris, 1858–'81), in twenty-four volumes, from which I have taken many citations.*

It is said by a writer in the fifth century that venesection was practised by the surgeons of the army of Agamemnon in the siege of Troy. The tradition is that Troy was besieged for ten years and fell 1183 B. C. (Eratesthenes); one writer, however, fixes the date at 1335 B. C., and another at 1149 B. C. In the time of Hippocrates (460–377 B. C.) bleeding was practised from several different veins, the situations of which were well known. Aristotle (384–322 B. C.) was the first to show that the vena cava and the aorta communicated with the heart and that the aorta carried blood. It is said, however, that the distinction between the arteries and veins was known before the time of Hippocrates and was described by Diogenes of Apollonia in the fifth century B. C.

It is somewhat difficult to ascertain exactly the notions of Aristotle in regard to the arteries. In his work, called in translation "History of Animals," he describes the passing of air from the lungs to the heart; while in his work, "On Parts of Animals," he describes two vessels arising from the heart, which, as well as the heart, are filled with blood. The two works referred to are generally accepted as authentic. Milne Edwards cites the following from the work, "History of Animals," as expressing the idea of Aristotle: "Vessels arise from the heart which go to the lungs, the branches of which divide like those of the trachea. . . . These branches have no communication

* Milne Edwards, "Leçons sur la physiologie," Paris, 1858, tome iii., p. 2, *et seq.*

with these vessels, but, by reciprocal contact, the vessels which come from the heart receive the air and pass it to the heart, where their trunks open." Milne Edwards says that Hippocrates, Aristotle, Herophilus, and Erasistratus (300 B. C.) distinguished between the arteries and the veins; that on examining dead bodies the veins are generally found gorged with blood, while the arteries are almost empty; and this circumstance had led all physiologists to think that the veins were the only blood-vessels and that the arteries were designed to carry air. Aristotle considered the latter tubes as forming, with the trachea, a vast system of pneumatic conduits. Hippocrates, however, was the first to describe the pulse; Aristotle recognized that the pulse was produced by the movement of blood. Herophilus studied the pulse more closely, established its synchronism with the heart and distinguished clearly the two kinds of vessels which "connected" the lungs with the heart. Erasistratus noted the play of the valves of the heart. This state of knowledge and conjecture, with many contradictions, remained until the time of Galen (130–200 A. D.). Galen noted that the arteries discharged blood when opened. He demonstrated experimentally the fact that the arteries carried blood by including a portion of an artery between two ligatures, opening the part of the vessel thus separated from the rest of the vascular system and finding that it contained blood only. Further observations led him to the conclusion that the liquid was not identical in the veins and arteries, although there were communications between the two systems of vessels which permitted the blood to pass easily from one to the other.

It is easy to imagine the disastrous effect upon learning of the destruction of the great libraries of the School of Alexandria, which contained about 700,000 rolls, or volumes. The library in the Bruchium is said to have been destroyed by fire in the year 47 B. C., when Cæsar burned the fleet in the harbor, the flames accidentally extending to the library. Most authorities agree that the destruction of the Serapeum, ordered by Theodosius in 391 A. D., completed the work of extinction. Following the disappearance of this, the greatest existing collection of rolls on all subjects and in all languages, there was a

long period of decline of learning. One can hardly wonder, then, that a great interval separated the work of Galen from the next important date in the history of the physiology of the circulation; namely, the description of the pulmonary circulation by Servetus, in 1553. The literature of the Middle Ages, extending from the decline of the Roman Empire to the revival of letters, or, according to Hallam, from the beginning of the sixth to the end of the fifteenth century, is very meagre; and it is easy to understand the difficulty of ascertaining the extent of common knowledge of physiology during the first half of the sixteenth century.

It is certain, however, that with the exception of the work of Servetus, the precursors of the discovery of the general circulation were almost entirely anatomical. In 1543 the great anatomist, Vesalius, corrected the error of Galen, who supposed that there were openings in the septum between the two ventricles of the heart. The valves of the veins were described by Étienne (1545), Cannanus (1551), Eustachius (1563), Piccolhominus (1586), and Fabricius (1603). Fabricius demonstrated the valves in the veins to Harvey, probably in 1601 or 1602. In a copy of Harvey's original work (1628), which I presented to the Astor Library, is the following manuscript note by a former owner: "The valves in the heart and veins, the famous Dr. Harvey told me, gave him the first hint of his grand discovery.—Boyle."

François Rabelais (1490?–1553), universally recognized as "the greatest of French humorists and one of the few great humorists of the world" (Saintsbury), in the third book of his collected works (the second book "Treating of the Heroic Deeds and Sayings of the Good Pantagruel"), gives an account in Chapter IV., in which "Panurge continueth his discourse in praise of borrowers and lenders," of the nourishment of the microcosm and its members by the blood. In the collected works of Rabelais there are but two passages in which reference is made to movements of the blood; but they are so striking, in view of the work of Servetus, published in 1553, that it has seemed to me important, in connection with the history of the discovery of the circulation, to study these passages closely and critically. The book referred to was published

in 1546, seven years before the date of the "Christianismi restitutio" of the unfortunate Servetus; and I find no reference to this by any writer on physiology. The remarkable passage, which I shall give in full farther on, is in one of the curious discourses of Panurge, the principal character in the books relating to Pantagruel. The writings of Rabelais, as they have come down to us, are works of quaintly extravagant and humorous fiction, in language which at the present day might be regarded as gross and even obscene; but measured by the standard of the sixteenth century, they can hardly be so considered. As appearing in a work of fiction, it is not to be expected that great care as to accuracy of scientific statement would have been exercised, as probably was the case in the serious work of Servetus; but it must be borne in mind that Rabelais was a physician, had a thorough knowledge of the Latin and Greek languages and had given public lectures in 1531 on Galen and Hippocrates. In 1532 he edited the "Aphorisms" of Hippocrates and the "Ars parva" of Galen; in 1537 he lectured on the Greek text of Hippocrates, and in 1538 he made a public anatomical demonstration. Saintsbury, who has given, probably, the best brief account of the works and character of Rabelais, writes as follows: "With an immense erudition representing almost the whole of the knowledge of his time, with an untiring faculty of invention, with the judgment of a philosopher and the common sense of a man of the world, with an observation that let no characteristic of the time pass unobserved, and with a tenfold portion of the special Gallic gift of good-humored satire, Rabelais united a height of speculation and depth of insight and a vein of poetical imagination rarely found in any writer, but altogether portentous when taken in conjunction with his other characteristics."

The beginning of the sixteenth century was also the beginning of the revival of letters. At the period when Rabelais and Servetus wrote, the accumulated learning of the world handed down to that time was to be found in a few works written in hardly more than two languages, Latin and Greek; and this is eminently true of scientific knowledge. The description of the pulmonary circulation by Servetus, in 1553, is certainly the most important event

in the progress of physiology which led to the discovery of the circulation in 1616. I have endeavored, in my study of the literature, to ascertain how far Servetus was in advance of the scientific knowledge common to the learned men of his time. Where could I find this condition of knowledge more faithfully represented than in such portions of the works of Rabelais as referred to the subject under consideration!

The following are the passages in the works of Rabelais in which reference is made to the movements of the blood. I have endeavored to present a literal translation from the original old French, and have made but little use of the well-known translation by Urquhart and Motteux, which, though admirable and most faithful, is not exactly word for word:

"La vie consiste en sang; sang est le siège de l'ame; pourtant un seul labeur poine ce monde, c'est forger sang continuellement. En ceste forge sont touts membres en office propre; et leur hiérarchie telle, que sans cesse l'un de l'aultre emprunte, l'un à l'aultre preste, l'un à l'aultre est debteur. La matière est métal, convenable pour estre en sang transmué, est baillée par nature: pain et vin. En ces deux sont comprinses toutes espèces de aliments. Et de ce est dict le companage en langue Goth. Pour icelles trouver, préparer et cuire, travaillent les mains, cheminent les pieds et portent toute ceste machine: les yeulx tout conduisent. L'appétit, en l'orifice de l'estomach, moyennant de mélancholie aigrette, que lui est transmis de la ratelle, admoneste d'enfourner viande. La langue en faict l'essai; les dents la maschent; l'estomach la recoit, digère, et chylifie. Les vènes mésaraiques en succent ce qu'est bon et idoine, delaissent les excréments, lesquells par vertus expulsive sont vidés hors par exprès conduicts; puis la portent au foye: il la transmue derechef, et en faict sang. Lors quelle joie pensez-vous estre entre ces officiers, quand ils ont vu

"Life consisteth in blood; blood is the seat of the soul; thus a single labor resteth upon this microcosm (monde), it is to make blood continually. In this workshop all the members are in proper function; and their hierarchy is such that incessantly the one borroweth from the other, the one lendeth to the other, the one is debtor to the other. The material is matter suitable to be converted into blood, is given by Nature: bread and wine. In these two are comprehended all kinds of aliments. And from this is said companage in the Gothic tongue. To find, prepare, and cook these, the hands work, the feet walk and carry the entire machine: the eyes conduct all. The appetite, in the orifice of the stomach, by means of the sourish black humor, which is sent to it by the spleen, admonisheth it to shut in the meat. The tongue maketh the first trial of it; the teeth chew it; the stomach receiveth, digesteth and chylifieth it. The mesenteric veins suck from it that which is good and fit, leaving behind the excrements, which by expulsive faculty are emptied out by special conduits; afterward it is carried to the liver: it there changeth once again, and of it is made

ce ruisseau d'or, qui est leur seul restaurant? Plus grande n'est la joie des alchimistes quand après longs travaulx, grand soing et despense, ils voient les métaulx transmués dedans leurs fourneaulx. Adonc chascun membre se prépare et s'estvertue de nouveau à purifier et affiner cestui thrésor. Les rognons, par les vènes émulgentes, en tirent l'aiguosité, que vous nommez urine et par les uretères la découllent en bas. Au bas trouve réceptacle propre: c'est la vessie, laquelle en temps opportun la vide hors. La ratelle en tire le terrestre et la lie, que vous nommez mélancholie. La bouteille du fiel en soubstraict la cholère superflue. Puis est transporté en une aultre officine, pour mieulx estre affiné: c'est le cœur, lequel, par ses mouvements diastoliques et systoliques, le subtilise et enflambe, tellement que par le ventricule dextre le met à perfection, et par les vènes l'envoye a touts les membres. Chascun membre l'attire à soi, et s'en alimente a sa guise: pieds, mains, yeulx, tout; et lors sont faicts debteurs, qui paravant estoient presteurs. Par le ventricule gausche il le faict tant subtile, q'on le dict spirituel, et l'envoye a touts les membres par ses artères, pour l'aultre sang des vènes eschauffer et esventer. Le poulmon ne cesse avecques ses lobes et soufflets le refraischir. En recognoissances de ce bien, le cœur lui en départ le meilleur, par la vène artériale. Enfin, tant est affiné dedans le rets merveilleux, que, par après, en sont faicts les esperits animaulx, moyennant lesquels elle imagine, discourt, juge, résoult, délibère, ratiocine, et rémemore."

. . . .

blood. Then what joy, think you, is amongst these officers, when they have seen this rivulet of gold which is their sole restorative? Greater is not the joy of alchemists when, after long labors, great care and expenditure, they see metals transmuted in their furnaces. Then every member prepareth itself and striveth anew to purify and refine this treasure. The kidnies, by the emulgent veins, take from it the aquosity which you call urine and by the ureters run it down. Below is found the proper receptacle: this is the bladder, which in convenient time emptieth it out. The spleen draweth from it the earthy part and the dregs, which you call black bile. The gall-bladder subtracteth from it the superfluous gall. Then is it transported to another workshop, in order to be better refined: this is the heart, which, by its diastolic and systolic movements, subtilizeth and heateth it, to such a degree that by the right ventricle it putteth it in perfection, and by the veins sendeth it to all the members. Every member attracteth it to itself and nourisheth itself from it in its own fashion: feet, hands, eyes, all; and then are made debtors, those which before were lenders. By the left ventricle it maketh it so subtile, that it is called spiritual, and sendeth it to all the members by its arteries, in order the other blood of the veins to warm and winnow. The lung ceaseth not with its lobes and bellows to refresh it. In acknowledgement of which good, the heart distributeth to it the best of it, by the arterial vein. Finally is it so much refined within the rete mirabile, that, thereafter, are made of it the animal spirits, by means of which it imagineth, discourseth, judgeth, resolveth, deliberateth, ratiocinateth, and remembereth."

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Œuvres de FRANÇOIS RABELAIS, Paris, 1857, Livre III., Chapitre iv., p. 152.

"Les philosophes et médicins afferment les esprits animaulx sourde, naistre et practiquer par le

"The philosophers and physicians affirm that the animal spirits spring from, have their origin in,

sang artérial purifié et affiné à perfection dedans le rets admirable, qui gist sous les ventricules du cerveau." *Ibid.*, Chap. xiii., p. 159.

and operate through the arterial blood purified and refined to perfection within the rete mirabile, which lieth beneath the ventricles of the brain."

If it is assumed that Panurge, in this part of his discourse, represented ideas in regard to physiology that were generally accepted by learned men in the middle of the sixteenth century, it is seen that some of their notions were nearly correct.

He says that life consists in the blood and that through the blood there is a passage of material from one part of the body to another; that the material suitable to be converted into blood is food (" bread and wine; in these two are comprehended all kinds of aliments "); that the tongue tastes it, the teeth chew it, the stomach receives, digests, and chylifies it, which is a fair summary of knowledge of these processes, even up to the second quarter of the nineteenth century; that the mesenteric veins take up the nutritive constituents of the food, and that the residue is discharged from the body; that it (the food) is carried to the liver and there changes (" and of it is made blood "—the nutritive matters are actually changed in the liver, but, of course, blood is not made in the liver); that the kidneys separate the urine from the blood, which is passed by the ureters to the bladder and is discharged " in convenient time "; that the spleen takes away the earthy parts and dregs, and the gall-bladder " the superfluous gall "; that in the right ventricle the blood is " put in perfection," and by the veins the blood is sent to all the members; that every member takes the blood and " nourisheth itself from it in its own fashion "; that the left ventricle makes the blood so " subtile, that it is called spiritual, and sendeth it to all the members by its arteries, in order the other blood of the veins to warm and winnow "; that the heart distributes the best of the blood to the lungs by the pulmonary artery (the arterial vein); that out of the blood the animal spirits are made in the chorioid plexuses. (In the second passage quoted it is evident that by the " rete mirabile, which lieth beneath the ventricles of the brain," is meant the chorioid plexuses; Servetus speaks of the chorioid plexuses and of their producing the animal spiritus from the vital spiritus.)

In brief, as regards the movements of the blood, Rabelais, in 1546, thought that the materials for the production of the blood were absorbed by the mesenteric veins from digested food and carried to the liver; that these matters were changed and made into blood in the liver; that the blood is brought to perfection in the right ventricle and is sent by the veins to all parts of the body for their nourishment; that the blood is subtilized in the left ventricle (in which part the vital spiritus is formed) and is sent by the arteries to "all the members" in order to warm and otherwise modify the blood sent to them by the veins; that the blood is sent to the lungs by the pulmonary artery; that the vital spiritus is changed into animal spiritus in the chorioid plexuses, by means of which (animal spiritus) the operations of the mind are conducted.

This was undoubtedly the condition of general knowledge of the movements of the blood up to the time of Harvey (1616). Vesalius, in 1543, three years before Rabelais, denied the existence of openings in the interventricular septum; but he made no notable physiological deductions from this most important anatomical observation. If this had been recognized in connection with the movements of the blood, knowing that the blood is carried to the lungs by the pulmonary artery, it would have been evident that the blood could reach the left side of the heart by no other way than by the pulmonary veins. Galen, in the second century, had shown that the arteries carried blood only and not air; which was well known to Rabelais and to some of the learned men of his time. As a matter of fact, the idea of the uses of the valves of the veins, which indicated the direction of the flow of blood in these vessels, was the idea which rendered it impossible to describe the movements of the heart and blood ("motus cordis et sanguinis") in any other way than as was described by the immortal discoverer of the circulation. The correction of the ancient error which admitted openings in the interventricular septum made the passage of blood through the lungs a logical necessity; and the discovery of the valves of the veins made the general circulation an unavoidable logical sequence; yet the importance of the anatomical description of the heart by Vesalius was not thoroughly comprehended by investigators for seventy-

three years (1543 to 1616); and the uses of the valves of the veins remained unknown for more than half a century.* The writings of Servetus had absolutely no influence on the discovery of the circulation; the physiological passages in the "Christianismi restitutio" were unknown until long after the publication of the "Exercitatio anatomica de motu cordis et sanguinis," in 1628.

Michael Servetus (Michael Seruetus, Miguel Serveto, Michael Villanovanus, or Miguel de Villeneuve) was born in Tutella, in Navarre, in 1511, and died in 1553. The history of Servetus, with his tragic death at the stake, is too well known to call for extended repetition here. He met Calvin in Paris in 1536 and had some discussion with him on theological questions concerning which Servetus had written in 1531 and 1532 ("De Trinitatis erroribus"). He corresponded with Calvin in 1545 and 1546. In January, 1553 he published the "Christianismi restitutio," of which but two perfect copies are known to be in existence. This book earned for Servetus the relentless enmity of Calvin. In March, 1553 he was interrogated by the inquisitor general at Lyons, having been arrested on the charge of heresy. Early in April he escaped from his prison. In August he was arrested in Geneva. On October 26th he was convicted and sentenced to be burned alive. The sentence was carried out October 27, 1553. It is said that copies of his book were burned at the same time.

The medical history of Servetus is important as bearing upon his authority as a scientific writer. It is recorded that he studied medicine in Paris, in 1536, under Günther, Dubois,† and Fernel. He succeeded the great anatomist Vesalius as assistant to Günther. Günther describes him as a man of high culture, specially skilled in dissection and with a profound knowledge of the works of Galen. In 1540 he entered the medical school at Montpellier. He acted as the private physician to Paulmier, archbishop of

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* The history of the discovery of the valves of the veins is somewhat obscure. The best information in regard to it is that Étienne described valves in branches of the portal vein in 1545; Lucitanus, in 1551, published a letter from Cannanus in which he described (probably in 1547) valves in certain veins; Eustachius described valves in the coronary vein in 1563, and Piccolhominus published a clear account of the valves of the veins in 1586. Fabricius published accurate descriptions and delineations of the valves in 1603.

† Dubois is known in literature as Jacobus Sylvius.

Vienna, from 1541 to 1553. He wrote a number of books on various subjects and among them a work containing six lectures on digestion and the composition and use of syrups. The first edition of this book was published in 1537, the fifth and last edition bearing the imprint: Venice, 1548. According to Alexander Gordon (" Encyclopædia Britannica," article " Servetus "), "the passage describing the pulmonary circulation is first noticed by W. Wotton, in ' Reflections upon Ancient and Modern Learning,' 1694."

I give here the original and a translation of the celebrated passage in the " Christianismi restitutio." The original Latin was reprinted by Flourens and afterward by Milne Edwards.* I have never seen a complete translation into English. The translation here given I believe to be absolutely literal and accurate as regards anatomical terms. In its preparation I have been more than assisted by Mr. Montgomery Schuyler, an accomplished scholar and littérateur, of New York:

" Vitalis spiritus in sinistro cordis ventriculo suam originem habet, juvantibus maximè pulmonibus ad ipsius generationem. Est spiritus tenuis, caloris vi elaboratus, flavo colore, ignea potentia, ut sit quasi ex puriori sanguinis lucidus vapor, substantiam in se continens aquæ, aeris et ignis. Generata ex facta in pulmonibus mixtione inspirati aeris cum elaborato subtili sanguine, quem dexter ventriculus cordis sinistro communicat. Fit autem communicatio hæc, non per parietem cordis medium, ut vulgo creditur, sed magno artificio à dextro cordis ventriculo, longo per pulmones duc-

"The vital spiritus has its origin in the left ventricle of the heart, the lungs in the greatest degree aiding its generation. This spiritus is attenuated, elaborated by force of heat, of yellow color, of fiery power, so that it is, as it were, a clear vapor from the purer blood, containing in itself the essence of water, air, and fire. It is generated from an admixture made in the lungs of inspired air with elaborated subtile blood, which the right ventricle of the heart communicates to the left. Indeed this communication is not made through the middle wall of the heart, as is commonly believed,

* In the " Encyclopædia Britannica," Sir William Turner, the writer of the article "Anatomy," reprints, in the original Latin, what purports to be the entire passage from Servetus. This reprint, however, is incomplete. Nearly one fourth of the passage—the last portion, which is important—is omitted. Also, there are many important variations from the text as given by Flourens and Milne Edwards. In addition, the extraordinary error is made of crediting the passage to a work, " De Trinitate " (probably " De Trinitatis erroribus ") instead of to the " Christianismi restitutio." These errors may be due to the fact that there are but two copies of the " Christianismi restitutio " known to be in existence, one in the National Library in Paris and the other in the Imperial Library in Vienna. I have never seen it stated that a copy is to be found in the British Museum. There is said to be an imperfect copy in Edinburgh, partly reprinted.

tu, agitatur sanguis subtilis : à pulmonibus præparatur, flavus efficitur, et à vena arteriosa in arteriam venosam transfunditur. Deinde in ipsa arteria venosa inspirato aeri miscetur et expiratione à fuligine repurgatur. Atque ità tandem à sinistro cordis ventriculo totum mixtum attrahitur, apta supellex, ut fiat spiritus vitalis.

"Quòd ità per pulmones fiat communicatio et præparatio, docet conjunctio varia et communicatio venæ arteriosæ cum arteria venosa in pulmonibus. Confirmat hoc magnitudo insignis venæ arteriosæ, quæ nec talis, nec tanta facta esset, nec tam à cordæ ipso vim purissimi sanguinis in pulmones emitteret, ob solum corum nutrimentum, nec cor pulmonibus hac ratione serviret; cum præsertim anteà in embryone solerent pulmones ipsi aliumdè nutriri, ob membranulas illas, seu valvulas cordis, usque ad horam nativitatis nondum opertas, ut docet Galenus. Ergò ad alium usum effunditur sanguis à corde in pulmones hora ipsa nativitatis, et tam copiosus. Item, à pulmonibus ad cor non simplex aer, sed mixtus sanguine mittitur per arteriam venosam; ergò in pulmonibus fit mixtio. Flavus ille color à pulmonibus datur sanguini spirituoso, non à corde. In sinistro ventriculo non est locus capax tantæ et tam copiosæ mixtionis, nec ad flavum elaboratio illa sufficiens. Demum, paries ille medius, cum sit vasorum et facultatum expers, non est aptus ad communicationem et elaborationem illam, licet aliquid resudare possit. Eodem artificio, quo in hepate fit transfusio à vena porta ad venam cavam propter sanguinem, fit etiam pulmone transfusio à vena arteriosa ad arteriam venosam propter spiritum. Si quis hac conferat cum iis quæ scribit Galenus, lib. vi et vii, 'De usu partium,' veritam penitus intelliget, ab ipso Galeno non animadversam. Ille itaque spiritus vitalis à sinistro cordis ventriculo in arteriis totius corporis deindè transfunditur,

but by great ingenuity from the right ventricle of the heart, by a long passage carried through the lungs, the subtile blood is put in motion : it is prepared by the lungs, is made yellow, and is transfused from the vena arteriosa to the arteria venosa. Thereupon, in the arteria venosa itself, it is mixed with the inspired air and by expiration is purged of its dark substance. Also in this wise at last from the left ventricle of the heart the whole admixture is drawn, material is adapted, so that it makes vital spiritus.

"Since the communication and preparation is thus made through the lungs, it teaches a manifold conjunction and communication of the vena arteriosa with the arteria venosa in the lungs. The remarkable magnitude of the vena arteriosa confirms this, which would be made neither such, nor so great, nor would it thus send out from the heart itself a force of the purest blood into the lungs, for the purpose of their nourishment alone, nor would the heart for this purpose supply the lungs; especially since previously in the embryon the lungs themselves were accustomed otherwise to be nourished, on account of these little membranes, or valvules of the heart, not yet opened even to the hour of birth, as Galen teaches. Therefore for another purpose, the blood is poured out from the heart into the lungs at the very hour of birth, and in such abundance. Likewise, air not simple, but mixed with blood, is sent to the heart from the lungs through the arteria venosa : therefore the mixture is made in the lungs. This yellow color is given to the sanguis spirituosus by the lungs, not by the heart. In the left ventricle there is no capacious place for so great and such copious admixture, nor is there elaboration sufficient for the yellow. Indeed, that middle wall, since it lacks vessels and facilities, is not adapted to communication and that elaboration, even if it could exude

ità ut qui tenuior est superiora petat, ubi magis adhuc elaboratur, præcipuè in flexu retiformi, sub basi cerebri sito, in quo ex vitali fieri incipit animalis, ad propriam rationalis animæ sedem accedens. Iterum ille fortius mentis ignea vi tenuatur, elaboratur, et perficitur, in tenuissimis vasis seu capillaribus arteriis, quæ in plexibus choroidibus sitæ sunt, et ipsissimam mentem continent. Ili plexus intima omnia cerebri penetrant, et cerebri ventriculos internè succingunt, vasa illa secum complicata et contexta servantes, usque ad nervorum origines, ut in eos sentiendi et movendi facultas inducatur.

"Vasa illa miraculo magno tenuissime contexta, tametsi arteriæ dicantur, sunt tamen fines arteriarum, tendentes ad originem nervorum, ministerio meningum. Est novum quoddam genus vasorum. Nam, sicut in transfusio à venis in arterias est in pulmone novum genus vasorum, ex vena et arteria, ità in transfusione ab arteris in nervos est novum quoddam genus vasorum, ex arteriæ tunica et meninge : cum præsertim meninges ipsæ suas in nervis tunicas servent."

Milne Edwards, "Leçons sur la physiologie," Paris, 1858, tome iii., p. 17.

anything. By the same arrangement by which transfusion is made in the liver from the vena porta to the vena cava through blood, a transfusion is also made in the lung from the vena arteriosa to the arteria venosa through spiritus. If one will compare this with that which Galen writes, lib. vi et vii, 'De usu partium,' he will thoroughly understand the truth not observed by Galen himself. This vital spiritus accordingly is transfused from the left ventricle of the heart and then into the arteries of the whole body, so that what is of greater tenuity seeks the superior, where it is still more elaborated, especially in the flexus (plexus) retiformis, situated under the base of the brain, in which from the vital begins to be made the animal, approaching to the proper seat of the rational soul. Again, this is more strongly attenuated, elaborated, and perfected by the fiery power of the mind, in the thinnest vessels or capillary arteries, which are situated in the chorioid plexuses, and contain the very mind itself. These plexuses penetrate all intimate parts of the brain, and gird from below inwardly the ventricles of the brain, preserving these vessels complicated and entwined with each other, as far as the origins of the nerves, in order that the faculty of feeling and of moving may be imparted to them.

"These vessels most delicately in a very miraculous manner interlaced, although they are called arteries, are nevertheless the ends of arteries extending to the origin of nerves, for the service of the meninges. It is a certain new kind of vessels. For, as in transfusion from veins to arteries there is in the lung a new kind of vessels out of vein and artery, thus in transfusion from arteries to nerves there is a certain new kind of vessels, out of the tunic of the artery and the meninx : especially as since the meninges themselves preserve their own tunics in the nerves."

In the first sentence of the extract from Servetus, he says, like Rabelais, that " the vital spiritus has its origin in the left ventricle "; Rabelais says that the left ventricle makes the blood so subtile that it (the blood) is called spiritual and the left ventricle sends it to all the members by the arteries to warm and " winnow " the blood of the veins. Servetus says that the lungs " in the greatest degree " aid in the generation of the vital spiritus; that it (the vital spiritus) is attenuated and elaborated by force of heat, is of a yellow color (" flavo colore ") and of fiery power, and is, " as it were, a clear vapor," containing the essential parts of water, air and fire.* " It (the vapor) is generated from an admixture, made in the lungs, of inspired air with elaborated subtile blood, which the right ventricle of the heart communicates to the left." This communication is not made through the middle wall of the heart, as is commonly believed, but from the right ventricle, " by a long passage carried through the lungs, the subtile blood is put in motion." It is prepared by the lungs, is made yellow and is passed from the pulmonary artery to the pulmonary vein.† The blood is mixed with the inspired air in the pulmonary artery " and by expiration is purged of its dark substance." In this wise the whole admixture is drawn from the left ventricle, " material is adapted, so that it makes vital spiritus."

Here is a description of the passage of dark blood through the lungs, from the right to the left side of the heart. In the lungs the blood is purged of " dark substance," which is thrown off in expiration and is changed into vital spiritus, described as a clear vapor, of yellow color. This is the idea of the pulmonary circulation given by Servetus.

Rabelais thought that the blood was made so subtile in the left ventricle that it was called spiritual and was sent by the left ventricle to the parts to " warm and winnow " the venous blood; which latter was also sent to the

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* Farther on, Servetus calls this " sanguis spirituosus."

† At the time of Rabelais and Servetus the general notion was that there was but one pulmonary vein. Eustachius made his celebrated " Anatomical Engravings " in 1552 ; but he was unable to publish them, and they were practically buried in the papal library until 1714, when they were made public by Lancisi. In Tab. XXVII., Fig. 13 is a very exact representation of the four pulmonary veins. (Sprengel, " Histoire de la médecine," Paris, 1815, tome iv., p. 35.)

parts for their nourishment, but by the right ventricle. Rabelais also spoke of the heart as distributing its best blood to the lungs by the pulmonary artery. He indeed came very near a description of the passage of blood through the lungs; and he actually did say that spiritual blood was sent by the left ventricle through the arteries "to all the members."

The arguments of Servetus to sustain his theory of the passage of blood through the lungs are most interesting. He says that since the communication and preparation of the vital spiritus is thus made through the lungs, there is a manifold conjunction and communication in the lungs of the pulmonary artery with the pulmonary vein; and that this is confirmed by the great size of the pulmonary artery, this vessel carrying too much blood to the lungs simply for their nourishment. He speaks of the lungs of the fœtus as "accustomed otherwise to be nourished," on account of valvules of the heart "not yet opened even to the hour of birth, as Galen teaches"; "the blood is poured out from the heart into the lungs at the very hour of birth, and in such abundance; the yellow color is given to the "sanguis spirituosus" by the lungs, not by the heart; the left ventricle is not sufficiently capacious for so great an admixture of air with the blood; the arrangement for the passage of blood in the lungs from the pulmonary artery to the pulmonary vein is the same as for the passage of blood in the liver from the vena porta to the vena cava. Indeed, in his argument, Servetus quite closely describes the changes in the pulmonary circulation which take place at birth.

It is not germane to my purpose to follow either Servetus or Rabelais through their speculations in regard to the generation of animal spiritus from vital spiritus. Servetus speaks of the animal spiritus as elaborated and perfected in the plexus retiformis under the base of the brain and as still more strongly attenuated, elaborated and perfected in the chorioid plexuses, describing the tunics of the vessels of these plexuses as uniting with the meninges to form nerves. Rabelais speaks of the animal spirits as made in the "rete mirabile" out of the spiritual blood: "The philosophers and physicians affirm that the animal spirits spring from, have their origin in, and operate through the

arterial blood purified and refined to perfection within the rete mirabile, which lieth beneath the ventricles of the brain."

One can hardly study closely the passages quoted from Rabelais without appreciating how near philosophers and physicians in the middle of the sixteenth century were to a knowledge of the pulmonary circulation. As regards the systemic circulation, the notion seems to have been that blood was made in the liver out of nutritive matters of food absorbed by the mesenteric veins, was transported to the heart to be further refined, and was sent to the parts by the veins; that the left ventricle sent arterial blood to the parts for some indefinite purpose. It remained to show that the blood could move in the veins in only one direction and could not pass from the right ventricle to the periphery, to give the key to knowledge of the general circulation. This was done when the great anatomist, Fabricius, demonstrated the valves in the veins to the great physiologist and philosopher, William Harvey.

The work of Servetus was not a factor in the discovery of the circulation, because it was unknown, it is said, until 1694. It might be said that the cruel burning of Servetus and the practical destruction of his work, in 1553, delayed the discovery of the circulation for more than half a century; but the history of physiology shows that Realdus Columbus, of Cremona, a disciple of Vesalius, wrote in 1559 that blood did not pass through the interventricular septum, but was carried from the right ventricle to the lungs by the pulmonary artery and then passed with air into the left ventricle by the pulmonary vein. Cæsalpinus, in 1583, wrote that the veins carried nutritive matters to the heart and that the arteries distributed these matters to the parts. He noted that when a vein was ligated, the vessel became swollen below and never above the point of ligature. He also wrote that the blood "circulated" in the lungs to pass from the right to the left side of the heart; but he had a vague idea only of the general circulation and adhered to the ancient error that there were openings in the interventricular septum through which the blood passed freely between the two sides of the heart.*

* Milne Edwards, *op. cit.*, tome iii., p. 19.

How far, then, a general knowledge of the description of the pulmonary circulation by Servetus would have hastened the discovery of the general circulation, if at all, it is impossible to determine.

The idea of this article suggested itself to me in reading the passage that I have quoted from Rabelais. After much study and bibliographical research, I have attempted to give an account of the progress of actual knowledge in regard to the movements of the blood, up to the grand epoch in physiology marked by Harvey, and especially the knowledge that prevailed in the middle of the sixteenth century.

LXIII

REMINISCENCES OF THE "FRENCHY" MURDER CASE

Published in the "New York Medical Journal" for July 26, 1902.

I WAS an expert witness in the so-called "Frenchy" murder trial in June and July, 1891. The prisoner was indicted under the name of George Frank. In the low resorts which he frequented he was known as "Frenchy." His real name was supposed to be Ameer Ben Ali. He assumed to understand no English and very little French, speaking Arabic only. A Mr. Sultan, of New York, acted as interpreter during the trial. Ben Ali was accused of the murder of a woman named Carrie Brown, known to her associates as "Shakespeare," a dissolute character of the lowest grade. She was found dead and slashed with a knife, in the morning, in a disreputable "hotel" in the lower part of the city. Ben Ali had been in the habit of going to this hotel. The woman went to a room in the hotel about midnight with a man who was not the prisoner. This man disappeared during the night and has not been discovered. Ben Ali was in a room in the hotel during the night, having come in about 1 A. M., and was seen to leave about 5 o'clock in the morning. He was arrested the following morning, April 24, 1891. The prisoner's room was opposite the room in which the murdered woman was found. I published a short account of this case in the "New York Medical Journal," July 11, 1891.

In general terms, the theory of the prosecution was that the prisoner had taken room 33 for the purpose of entering other rooms during the night and gratifying his passions with women whom he might find alone; that he had entered room 31 at some time during the night and had found Carrie Brown after her male companion had left her; that for some reason he had become enraged at

the woman, had taken her by the throat and strangled her; that the mutilations, etc., were evidences of a certain ferocity of temperament not to be wondered at in a person of his character and previous record; that after the murder he had returned to room 33 and had left the hotel early in the morning without attracting particular attention. The murder was discovered about 10 A. M.

The theory of the defense was that the woman was killed by her male companion, who disappeared during the night; that it could not be shown that the stains on the prisoner's clothing were blood mixed with intestinal contents; that the blood on the prisoner's shirt was to be explained by something which occurred the night before.

Ben Ali was convicted of murder in the second degree and sentenced to imprisonment for life. He spent part of his time in prison and part in the asylum for insane criminals. Lately, while in prison, his sentence was commuted and he has left the United States. While in confinement he learned some English. I can not ascertain that he made any confession during his confinement, but have heard that he strenuously denied his guilt.

I took up the study of his case June 26, 1891, and became associated with Dr. Edson, then of the Health Department, and with Dr. Formad, of the University of Pennsylvania, who has since died. We examined specimens of matters taken from under the long finger nails of the prisoner four days after the murder, stains from the flaps of the prisoner's shirt, from the right sleeve of the shirt, from the back of the shirt, from the left sleeve of the shirt, from the wallpaper on the hall near the door of room 33, from the door itself, from the floor of room 33, from the prisoner's socks, from a chair in room 33, from the floor between room 31 and room 33, from the bedticking in room 33, from a knife found in room 33, from the bedtick under the murdered woman in room 31, from the stockings of the murdered woman, from a petticoat tied about the head of the murdered woman, and from the sheet on the bed in room 31. The prisoner occupied room 33 on the night of the murder. The murdered woman was found in room 31.

In all of these specimens mammalian blood was found, presumably human blood. On the prisoner's shirt, the

ticking of the bed in room 33, the woman's stockings and petticoat, nothing but blood was found. In all the other specimens blood was found mixed with more or less unchanged coloring matter of bile, fat globules and crystals, tyrosin, cholesterin, triple phosphates, columnar epithelium, eggs of round worms, starch granules, partially digested muscular tissue, and partially digested vegetable matters. The specimens containing these matters included those taken from under the finger nails of the prisoner.

Before I became associated in the case, the theory of the experts was that the intestinal matters found in the various specimens came from the large intestine. Indeed, the experts at that time understood that a piece of intestine cut out by the murderer was from the large intestine, containing fecal matter and residue of food, and not from the small intestine, which should contain partially digested matters and unchanged coloring matter of bile. After examining these specimens, I insisted that the matters came from the small intestine; although I was assured most positively that the records of the post-mortem showed that the large intestine only had been cut. However, I sent for the actual report of the autopsy and found the record that a portion of the lower part of the small intestine had been cut out, the large intestine being uninjured. Before I had ascertained this I had given a positive opinion that the ileum had been cut. This opinion was exactly confirmed by the official record.

On the witness-stand I testified substantially to the following facts and conclusions:

1. That the specimens examined by me contained tyrosin, bilirubin, columnar epithelium, partially digested muscular tissue and vegetable substances, microörganisms, etc.

2. That the tyrosin and bilirubin must have come from the small intestine, while the other matters might exist as well in the large intestine.

3. That the tyrosin was produced by the prolonged action of the intestinal digestive fluids upon the proteids of food, these matters being first converted into trypsin peptones and afterward into tyrosin, the change into tyrosin being aided by the action of intestinal microörganisms.

4. That the bilirubin, which strongly colored the epithelial cells and other matters, was characteristic of the contents of the small intestine.

5. That the appearances were practically the same in all the specimens.

My opinion that these matters were from the small intestine was based mainly on the presence of tyrosin and bilirubin.

I further testified that after matters passed from the small into the large intestine, tyrosin ($C_9H_{11}NO_3$) was changed into indol (C_8H_7N), and that bilirubin ($C_{16}H_{18}N_2O_3$) was changed into stercobilin ($C_{32}H_{40}N_4O_7$), or hydrobilirubin, and became brown instead of yellow, that the recognized matters peculiar to the feces were indol, skatol (which has the peculiar fecal odor), phenol and stercorin, which last substance I discovered in 1862. It was considered important to determine the exact source of the intestinal contents, because the defense assumed that fecal matter might be found under the finger nails in a person of grossly unclean habits. The changes which result in the formation of tyrosin in the small intestine and its further change in the large intestine are recognized by all physiologists. Tyrosin is found in health in other parts, as in the substance of the spleen, pancreas, and liver; and in certain diseased conditions it may be found also in other situations. In perfectly normal digestion tyrosin is by no means constant in the small intestine; but it is very seldom found in the feces, and then only in some kinds of diarrhea and in Asiatic cholera.

Bilirubin (the unchanged coloring matter of the bile) is always found in the small intestine, if bile is discharged into the upper part of the intestinal tract. It does not exist in the feces; and stercobilin, which is brown in color and is produced by a change in bilirubin, will not respond to the tests for the unchanged coloring matter. There are exceptions, however, in certain pathological conditions, especially when the feces are green or bright yellow. The appearance of partially digested meat and vegetable articles was consistent with testimony showing when and what the murdered woman had last eaten.

From a strictly logical and scientific point of view, the chain of evidence connecting matters found on and about

the person and room of the murdered woman with matters found on and about the person and room of the prisoner (even to the scrapings of the finger nails), the doors of the rooms, and the passage on the floor between the rooms seems to be absolutely complete and unbroken.

NOTE.—The novelty of the testimony in this case, the unfamiliar anthropological type of the accused, the unusually brutal character of the crime and the great interest in the prisoner on the part of some who believed him innocent and who finally secured his release seem to me to justify the republication of this article, although it is simply a condensation of Article XXXIV.

It has been rumored that the prisoner made a confession to the person who interpreted his testimony at the trial and that the interpreter had told of this to several friends ; but the interpreter is dead and the story of a confession can not be verified. It was said, also, that new evidence had been discovered implicating the unknown man who accompanied the murdered woman to the hotel. Finally, largely through the efforts of the French embassy to the United States, the Governor of the State of New York was induced to commute the sentence on April 16, 1902, and the prisoner was discharged on April 19, on the ground of a reasonable doubt of guilt. It is said that the new evidence was the finding of what was assumed to be the key of room 31 in a lodging room occupied by an unknown sailor at about the time of the murder ; but this story was not subjected to legal investigation.

In both articles on this case, I have refrained as much as possible from either expressing or implying an opinion and have only recited my testimony, which was not impaired by cross-examination.

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